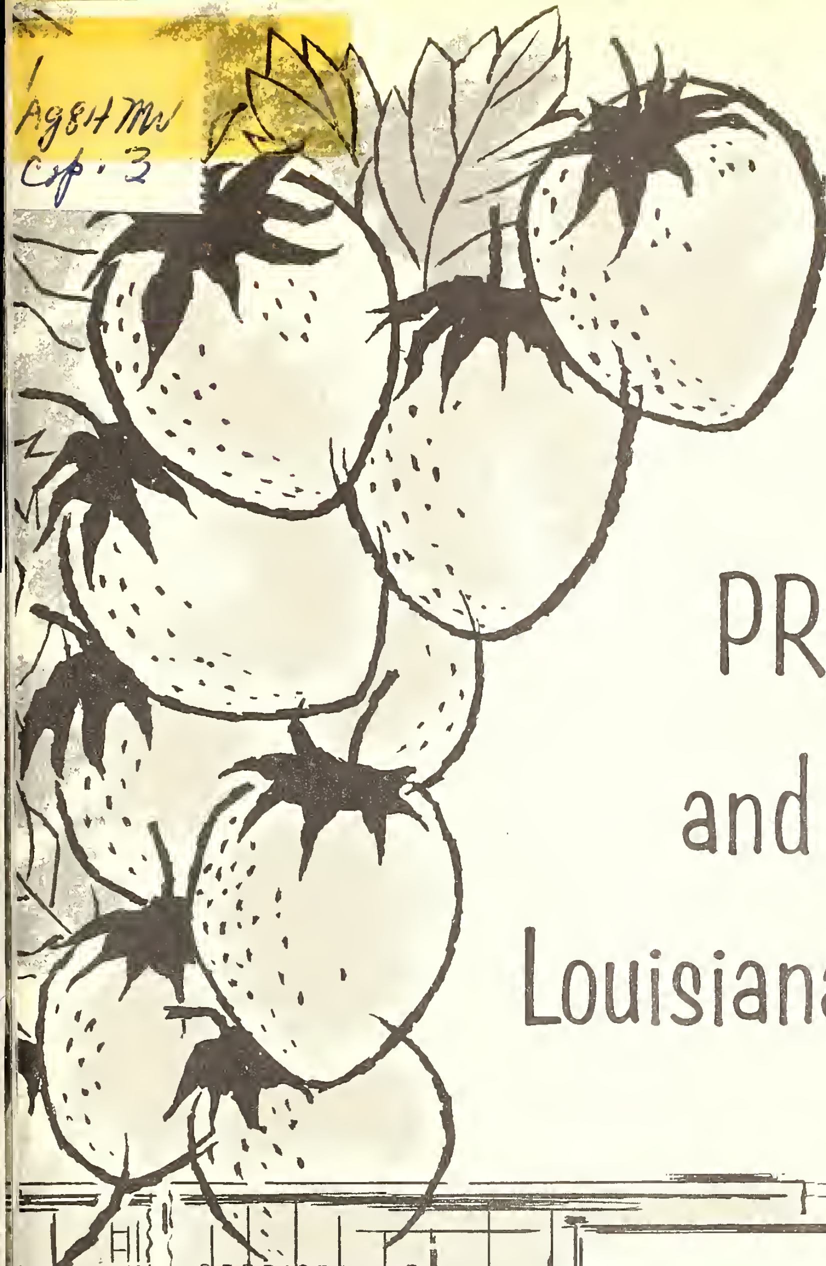
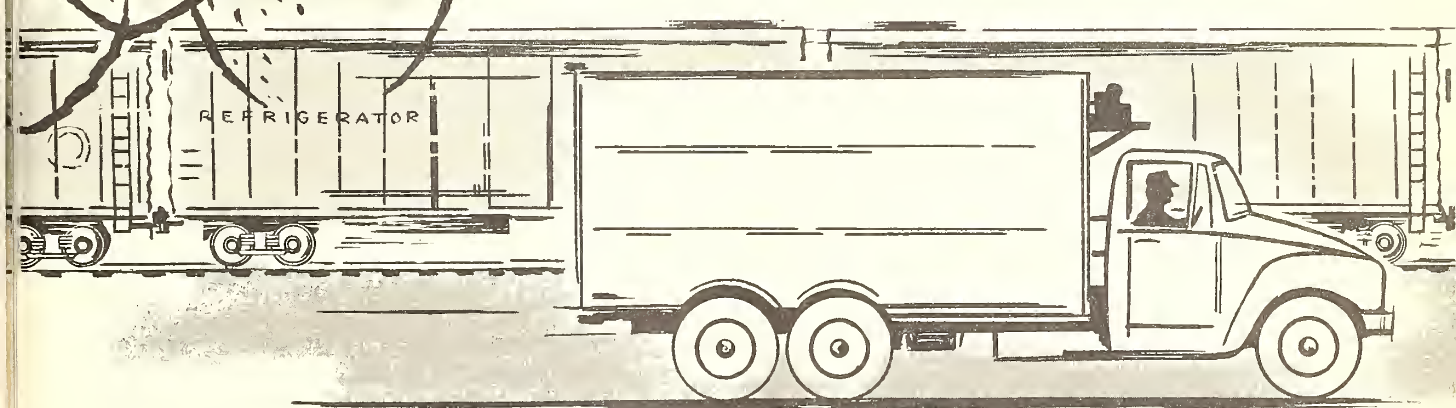
MARKETING RESEARCH
REPORT No. 358



PRECOOLING and SHIPPING Louisiana Strawberries



U.S. DEPARTMENT OF AGRICULTURE

AGRICULTURAL MARKETING SERVICE ● MARKETING RESEARCH DIVISION

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PRECOOLING AND SHIPPING LOUISIANA STRAWBERRIES

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SUMMARY

Methods used in precooling and shipping Louisiana strawberries were studied in 26 tests on precooling and 26 on shipping (17 by rail and 9 by truck). In addition, tests were conducted in cooperation with Louisiana State University on experimental fiberboard containers, and on the performance of fans for precooling the berries in the car before shipment. The research was undertaken to determine how effective improved express cars and trucks can refrigerate strawberries in transit, and the amount of precooling in vehicles that is necessary before shipment begins. The study is a part of a broad program of research aimed at expanding the market for farm products.

Refrigerated express cars loaded with berries were "precooled" with ice and fans anywhere from 1.5 to more than 5 hours before shipment. Although the fruit at the doorway in some of the tests had reached 40° F. (the temperature desired before releasing the car for transit movement) at the end of the time allowed for precooling, in most instances the temperature of the berries throughout the cars ranged from 44° to 61°. The berries cooled faster when portable fans and car fans were used simultaneously. When the bunkers were not refilled with ice immediately before the fans were started for precooling, the rate of cooling was retarded. If ice was added during the operation, the fans had to be turned off, and much time was lost. Sometimes insufficient amounts of salt were added; also more care should have been exercised in properly working the salt into the ice.

Cooling of the berries with built-in fans after the cars got underway took place at about half the rate of that during precooling. In most of the test cars the average berry temperature was reduced to at least 40° F. by noon of the first full day in transit (the day after loading). This appears to be satisfactory.

The amount of dry ice normally used (400 to 500 pounds) was not considered sufficient to reduce transit deterioration.

Greater cooling in transit was obtained when salt was added to the ice just prior to departure of the car from shipping point, and at least at the first reicing in transit. The amount of decay in the berries when they arrived at destination was generally less in cars in which the most rapid cooling and lowest transit temperatures were attained. The channeled-type loading pattern allowed satisfactory cooling and caused little damage to the containers in transit, in both rail cars and trucks.

Berries shipped in trucks were not cooled as fast as those precooled in the express cars. However, when better than average equipment was used in a truck, and close attention given to the icing, the transit cooling rate was nearly as great as in car precooling. In most tests, the average berry temperature in the load did not reach 40° F. until midnight of the first full day in transit (the day after loading), while in others, this temperature was never reached.

It was found that when the built-in car fans were supplemented by the portable precooling fans, air movement was increased about 35 percent. When using this combination

[1] Mr. Redit is senior mechanical engineer; Mr. Hamer, engineering aid.

of fans, leaving the corner car fans uncovered gave 59 percent more air flow than when these corner fans were covered with the canvas baffles used with the portable fans. If the car fans were operated by a 2-HP motor instead of a 1-HP motor, the fan output increased 25 percent.

Berries in experimental fiberboard trays cooled as well as those in the standard wirebound crate.

BACKGROUND

Strawberries are highly perishable and are susceptible to rapid deterioration and decay. It is necessary to cool them as rapidly as possible after harvest and to maintain a low temperature during transit. Louisiana strawberries shipped by express cars are cooled in the car immediately after loading and before the car moves in transit. This precooling is done by means of portable fans alone or these fans in combination with built-in car fans. The ice in the car bunkers is the cooling agent. Berries shipped by ice-refrigerated trucks or trailers are cooled en route and are not held for precooling at the loading point.

During the 1956 season, the Louisiana Strawberry Commission and the sales agencies required that berries located at the doorway position be cooled to 40° F. before express cars could be released to the railroad for movement to market. Many cars had to be held past the normal pickup time for further cooling because fruit temperatures were still above 40°. This caused up to 12 hours' delay in delivery at destination when cars were not forwarded until the following morning. Shipping tests were therefore conducted to determine whether the ice and car fans could continue to cool the berries to a desirable temperature quickly enough in transit, after the usual precooling operation.

Earlier studies on shipping strawberries, conducted by the Louisiana State University from 1938 to 1940, showed the value of precooling, and indicated satisfactory rail transit temperatures were maintained only when the berries had been thoroughly precooled. [2]

Trucks were permitted to depart as soon as they were loaded with warm berries. However, satisfactory temperatures were not obtained in many truck shipments even when the loads had been precooled with mobile mechanically refrigerated precooling units.

Since these early studies were made, express cars have been equipped with built-in fans capable of cooling them rapidly after their movement to market begins. Trucks and trailers have been improved and their refrigerating capability increased by means of larger bunkers holding up to 2,000 pounds of ice and having gasoline-engine-driven air circulating fans. Information on the effect of these improvements on conditions in transit was needed.

The Louisiana State Marketing Commission and the Louisiana Strawberry Commission requested further studies which were begun during the 1957 season. The objective was to test the effectiveness of precooling berries in express cars and the continued cooling of the berries in transit by the car fans and ice; also to determine the rate of cooling that takes place in trucks in transit. This research is part of a broad program aimed at expanding the market for farm products.

During 1957, 12 tests were conducted on precooling in express cars, 2 on shipping by rail in express cars, and 9 on truck shipping of strawberries. The berries were shipped from the Hammond, La., to midwestern and eastern destinations. The work was

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[2] Barr, H. T., and Poole, W. D. Precooling of Strawberries. La. Bul. No. 331, La. State Univ., March 1941.

continued in 1958, when 14 precooling tests and 15 shipping tests were made in express cars. In addition, some preliminary air output tests of portable precooling fans and car fans were made in cooperation with the Agricultural Engineering Department of Louisiana State University.

Other tests on the respective merits of fiberboard trays and the standard wirebound crates for strawberry shipping were conducted in cooperation with the Department of Agricultural Economics of Louisiana State University. Precooling and transit temperatures of strawberries packed in these containers were obtained.

EQUIPMENT AND PROCEDURE

Equipment

The express refrigerator cars used in the rail movement of Louisiana strawberries are generally similar to freight refrigerator cars in design. However, they are equipped for high speed passenger train operation. Refrigeration is provided by ice bunkers at each end of the car which have a normal capacity of from 12,900 to 14,280 pounds of ice per car. All cars used in these tests were 50-foot cars equipped with built-in air circulating fans. These fans were of two types; the so-called mechanical floor type and the electric bulkhead fans.

The floor type fans contained seven blower fan units mounted on a single shaft. The shaft was in a housing extending the full width of the car floor and was flush with the floor racks. Two such fan assemblies were located about 3 feet from the bulkheads, one in each end of the car. Each set of fans operated independently and was belt driven directly from a friction drive wheel contacting a car wheel. In cars equipped with these floor fans, the top openings in the bulkheads separating the ice bunkers from the loading space extended the full width of the car with no obstructions other than the bulkhead posts and screens.

The electric type fans were mounted in circular openings at the top of each bulkhead, generally three at each end of the car as shown in figure 1. In some of the newer cars, the installation of a door to the ice bunker necessitated elimination of the center fan so these cars had a total of only four fans. These were propeller type fans, each mounted on and driven by individual electric motors. All fan motors derived their power from a single generator or alternator located under the car at one end. This was driven off the car wheel by a friction drive wheel similar to that of the floor fan unit.

As these fans operate only when the car is in motion, portable electric motors are provided for their operation when the car is standing. These are used during precooling at the loading point or when the car is held on track at destination prior to unloading. These motors are mounted on special brackets under the car. The fan shaft of the floor type fans and the alternator of the electric fan system are belt driven by these motors. Two such motors are required for the floor type fans, one at each end of car, while only one is necessary for the electric fans.

The customary precooling practice in this area is to operate the portable precooling fans and the car fans simultaneously. This practice was followed in these tests with one exception; in that test, car fans only were used.

Most truck shipments were made in so-called 10-wheel trucks. These truck bodies are usually around 20 feet in length and contain one ice bunker in the front end holding from 1,800 to 2,100 pounds of ice, although one test truck had a 3,000-pound capacity bunker. Air circulation was provided by a blower mounted in the top of the ice bunker which forced the cool air from the bunker over the top of the load and drew it back into the bottom of the bunker and up through the ice. This blower was driven by a small air-cooled gasoline engine mounted on a shelf outside the nose of the truck body. Semi-trailers were also used, varying in length from 24 to 32 feet. These trailers were

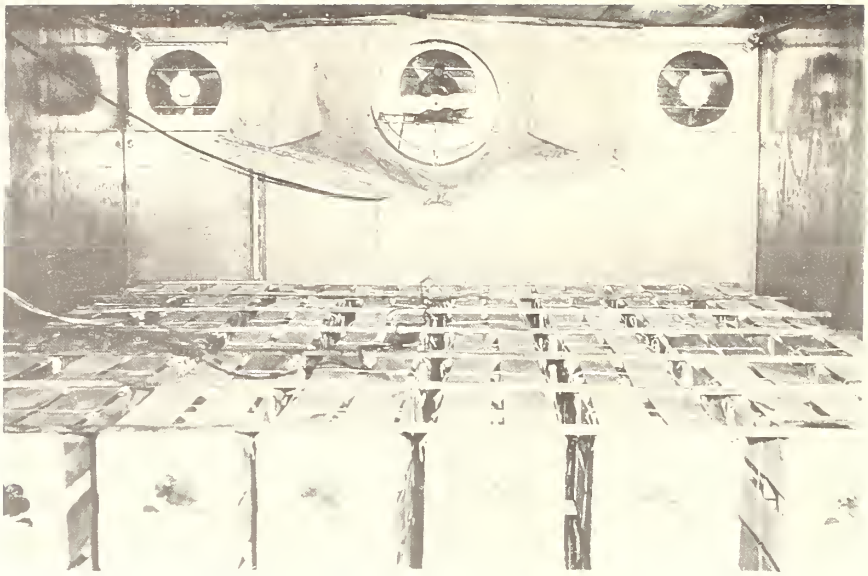

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Figure 1.--Portable precooling fan with corner car fans uncovered. The canvas air delivery duct is removed.

provided with ice bunkers and blowers similar to those in the trucks. All vehicles supposedly contained from 2 to 3 inches of insulation. No floor racks were provided in the trucks or trailers but most of them had wooden strips on the floor spaced 1/2 to 1 inch apart.

Loading

The berries were packed on the farm in standard 24-pint wirebound crates (except where fiberboard trays were tested) and were brought in for loading directly into the cars. The loads varied from 606 to 768 crates per car; the standard load is 736. The crates were loaded lengthwise 8 wide and 4 high with 23 stacks in the standard load and were braced at the doorway. Brace length varied according to the total number of crates; for the 736-crate load, it was 3 feet. A lengthwise vertical channel 2 to 4 inches wide was provided between each row and at side walls for air circulation. Each layer was double stripped with only the top layer strips nailed.

In the trucks and trailers, 2- to 3-inch vertical channels extended continuously lengthwise from front to rear in all layers except the top one which was solid. In this way all air discharged from the blower in the front end was forced to travel over the top of the load to the rear of the loading space and back to the bunker through the channels. An open space was left between the load and the rear doors. This space varied from 2 inches to several feet depending on the number of stacks in the load. Strips for the top layer and for every other layer were nailed in place. Size of load varied from 440 to 875 crates.

Car precooling tests

Precooling in the express cars was generally done by using portable fans operated together with the car fans in order to obtain a greater velocity and movement of air for more rapid cooling of the berries. The portable units were suspended at the bulkhead top openings in the floor-fan cars and over the center electric fan in cars so equipped. These two-bladed portable fans were 18 inches in diameter, each powered by a 1/2- or 1-HP electric motor. Canvas baffles, attached to the fan mountings, were used to cover the bulkhead openings so that all the air would be drawn from the ice bunkers (fig. 2). However, when used in conjunction with the electric car fans, the outer or corner car fans

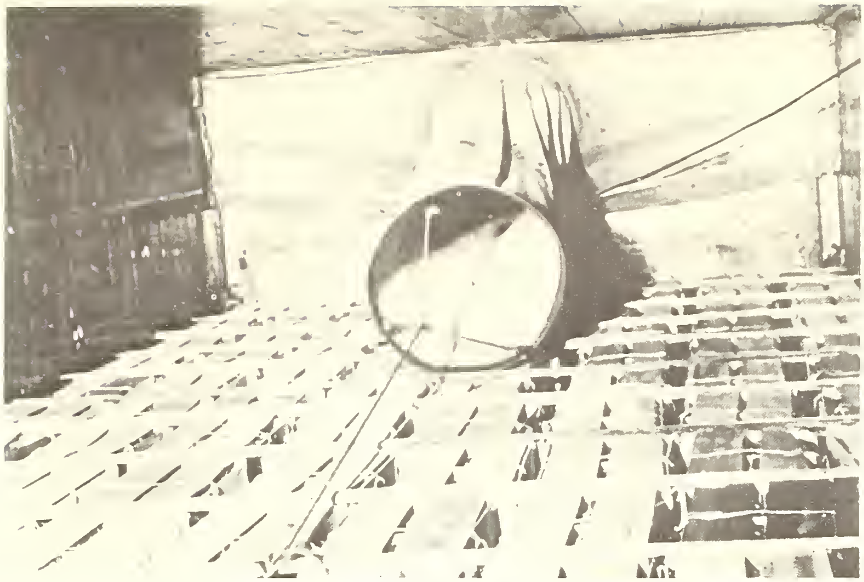

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Figure 2.--Portable precooling fan and air delivery duct with canvas baffle covering corner car fans.

were frequently left uncovered by the baffles. (fig. 1). When the electric car fans were not operated during precooling, the corner ones had to be covered. In the new cars that had only four electric fans, all of them had to be covered, whether they were operating with the portable units or not. Some of the portable fans were equipped with canvas discharge ducts, extending to the quarterlength of the car. In some cars the ends of the ducts were tied to the ceiling, in others, to the top of the load. The purpose of the ducts was to direct the air at high velocity to the doorway. In most tests, the car fans were operated by a 1-HP electric motor driving the alternator of the electrical system; or a 1-HP motor driving each floor-type fan. In one test, where only the electric fans were operated, a 2-HP motor was used.

Thermocouples installed during loading were read outside the car at intervals during the precooling period. Nine fruit and two air temperatures were taken in one end of each car. The fruit temperatures were taken by inserting a thermocouple in a berry at the center of a pint box near the middle of a crate located in the top, bottom, and third layers of the bunker, quarterlength and doorway stacks. All of these positions were in the center line of the car. Air blast temperatures were taken in the discharge from the portable fan while the return air temperature was taken at the bottom bunker opening under the floor racks. Hand thermometer temperatures of the berries were taken periodically during loading, and in crates in the doorway after precooling.

The cars were usually preiced at McComb, Miss., the afternoon before loading, and were placed for loading around 7 a.m. the next morning. However, during the 1958 season, all cars loaded at Ponchatoula were preiced on track after placement. On days when a greater volume of berries was received than expected, or when usual icing fell behind the demand, some cars were iced just before or during loading. Time of reicing varied considerably, ranging from no reicing until after precooling to reicing before and during precooling. Salt supplied under transit protective services was generally added at preicing based on a percentage of the bunker capacity, and at reicing on the basis of the amount of ice added. From 200 to 400 pounds of additional salt was added for precooling purposes by the precooling operators. Several grades of salt were used ranging from fine to coarse, with the coarse or more desirable grade predominating.

Dry ice was used in all rail shipments. It was usually placed in the brace at the doorway, either on the floor or on a shelf across the top of the brace. It was generally supplied before precooling started but in many instances it was not placed in the car until precooling was nearly completed, depending on the time it was delivered. During 1957 some of the dry ice was placed in the bunkers on top of the water ice in four test cars. The concentration of CO_2 gas produced by the dry ice during precooling was determined from a sample of the car air withdrawn through a copper tube inserted at the doorway.

Rail shipping tests

Transit temperatures were obtained by small recording thermometers, each replacing one pint of berries near the center of a standard crate. Although the thermograph registered air temperatures, it is believed that it recorded closely the actual fruit temperature at this position. One thermograph was placed in a crate located in the bottom layer in the bunker stack, another in the third layer in the quarterlength stack, and a third one in the top layer of the doorway or brace stack, all in the center line and in one end of the car. The test cars were met at destination, the instruments recovered, and the loads inspected by representatives of the Biological Sciences Branch in New York and Chicago and by inspectors in the State-Federal Inspection Service in the other cities.

Truck shipping tests

Transit temperatures in the trucks were also obtained by small recording thermometers similarly placed in crates located at the bottom bunker, middle half, and top doorway positions. The drivers kept records of icing, travel time, and weather conditions. All vehicles were iced at different times before loading and the ice was replenished soon after loading but before the start of the trip. In some cases the truck blower fan was operated at slow speed after the truck was about one-half loaded. Dry ice was placed on the ice in the bunkers in some tests. All truck shipments moved either to Chicago or New York and were inspected by Biological Sciences Branch personnel located at these markets.

RESULTS

The data of the two season's work are compiled in tables 1 to 10 (Appendix). For the precooling tests, records were made of loading details and fruit temperatures (tables 1 and 2), icing and salting (tables 3 and 4), and air- and fruit-temperatures (tables 5 and 6). Detailed fruit temperatures during rail transit are presented in table 7 and cooling rates in table 8. Loading data and transit temperatures for the truck tests are shown in tables 9 and 10.

Car precooling tests

As in commercial practices, there was considerable variation between the tests in precooling time, amount and time of salt application, time of preicing and reicing the cars and of the installation and use of the precooling fans. This makes it difficult to make a direct comparison between any two tests.

Cooling Rate

In most of the tests where cars were precooled for more than 3 hours, some berry temperatures at the doorway were found to be near 40° F., the temperature desired before the car goes forward. However, most of the fruit elsewhere in the car was at a higher temperature. Top layer strawberries usually cooled more rapidly than those in the middle or bottom layers as is shown in figure 3 which gives the results in two typical cars. The degree of cooling was dependent primarily on length of precooling time. The results from all tests were averaged and the degree of cooling plotted against precooling time (fig. 4). This graph shows the need for sufficient time for effective precooling.

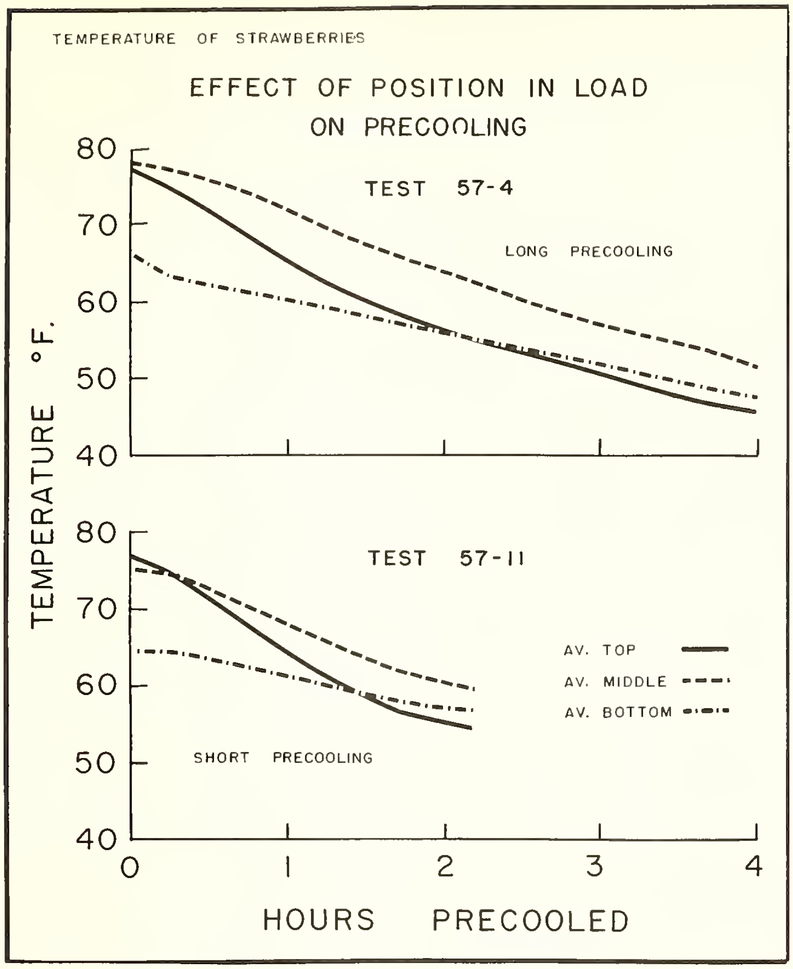

Figure 3

The number of interruptions for icing during precooling was a serious problem. In some cases the fans were off for over an hour during reicing.

Fans

As previously noted, all cars used in these tests were equipped with built-in fans, and they were usually operated to supplement the output of the portable precooling fans. Figure 5 compares the cooling that resulted when portable fans only were used, when car fans only were used, and when both were used together. Considerably more cooling resulted when both types of fans operated simultaneously. When both were used and the canvas baffles of the portable fans covered the two corner electric car fans (fig. 2), less cooling resulted than when these corner fans were left uncovered (fig. 1). This difference in cooling is shown graphically in figure 6. In cars equipped with floor-type fans, in which the top bulkhead openings extended the full width of the car, there was a much greater area through which the cooled air could be drawn out of the bunkers than in cars with electric fans.

The loads in the new cars equipped with only four built-in fans were cooled at practically the same rate as those with the usual six when the portable fans were used in conjunction with them.

One test was run using car fans only (fig. 5). The cooling rate in this car was slightly lower than that obtained in cars precooled with portable fans only, but further tests will be necessary to evaluate fully the use of car fans only in precooling strawberries.

Icing and salting

Icing the cars was one of the greatest problems in precooling strawberries in Louisiana. At one loading point all preicing was done by the local ice company and because the homemade equipment (fig. 7) broke down and crews were inexperienced, cars were not iced in some cases until shortly before loading. In a number of instances, the cars were reiced during the precooling period, and the fans were shut down for as long as an hour. When the bunkers were not filled immediately before the precooling fans were turned on the result was low ice in the bunkers, high air-blast temperatures; and very poor cooling. Also, because the salt for precooling was usually added during reicing, precooling was started without benefit of the salt. In cars where the ice remaining in the bunkers was not broken down properly before reicing, excessive voids resulted and the full amount of ice required could not be added. In many cases little effort was made to add and mix the salt with the ice properly, an important procedure in obtaining low temperatures. Unless a car had been reiced near the end of precooling, it was again reiced just before it was pulled from the loading track and more salt added if the transit refrigeration service included salt.

Air-blast temperatures

Rapid cooling requires low air-blast temperature and bunkers should be filled with ice and the proper amount of salt added before precooling fans are started. For most

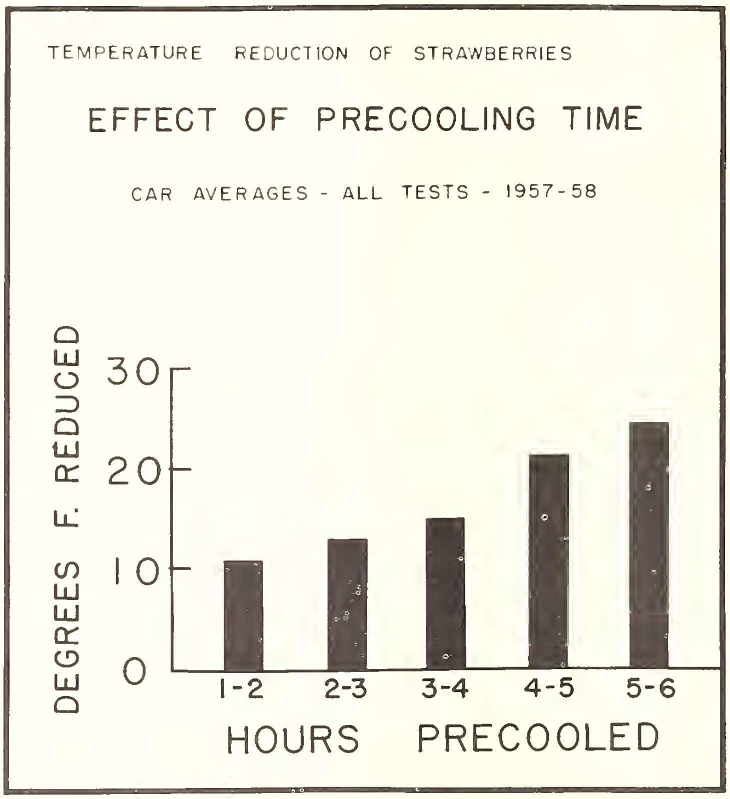

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Figure 4

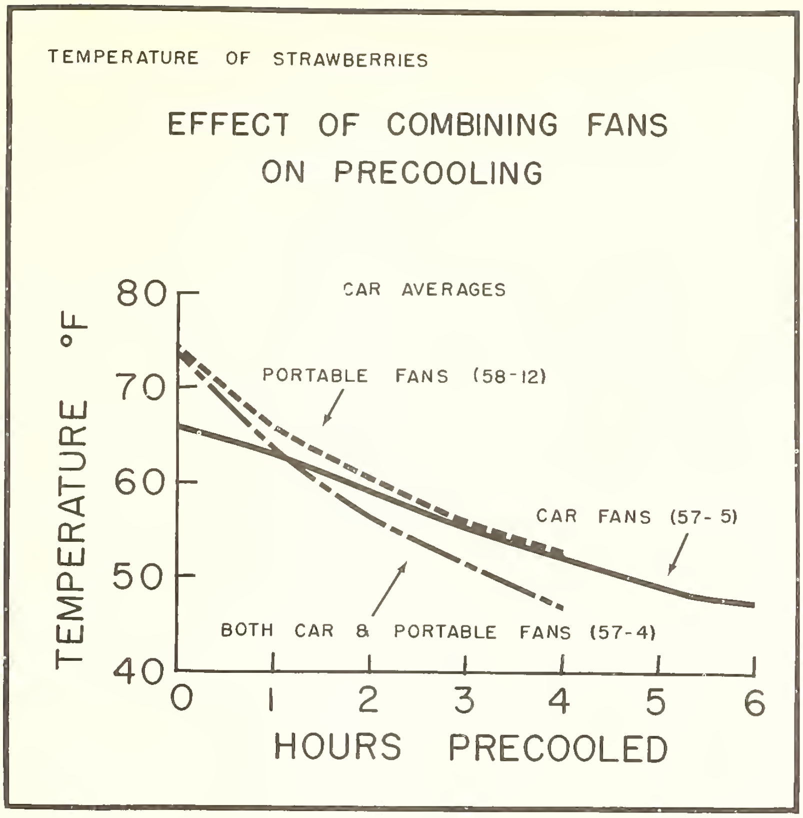

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Figure 5

effective use of salt, it must be thoroughly tamped or worked into the ice to promote rapid solution and formation of brine. Salt that does not dissolve is of no use. Tables 5 and 6 show air-blast temperatures at the start and finish of precooling. Tables 3 and 4 give the amount of salt used for precooling and the time it was added. In the car in test 57-12 (table 5), 300 pounds of salt was added at the start and resulted in a 37.5° air-blast temperature, while in test 57-10, with 108 pounds added 1 hour and 10 minutes after start, initial air-blast was considerably higher (52.5°). In test 58-12 (table 6), 300 pounds of salt was added at the start of precooling and the resulting air-blast temperature at this time was 40.5° On the other hand, in test 58-7, 200 pounds of salt was not added until 1 hour and 15 minutes after precooling started, and the initial air-blast temperature was 53.0° (12.5 degrees higher than in test 58-12). These comparisons show the importance of adding salt at the proper time for effective precooling. Bunkers full of ice are also imperative. Figure 8 shows the relatively high air-blast temperature as a result of low ice and no salt and the rapid drop in air-blast temperature after the car was reiced and salt added at about 3:30 p.m.

Dry ice

The application of dry ice during precooling had no appreciable effect on temperatures. In a limited number of observations, the maximum build-up of CO_2 gas concentration during precooling was about 4.5 percent which usually occurred about 2 hours after the dry ice was placed in the car. Even this low concentration was probably lost when the car doors were opened to remove precooling fans and check temperatures. Placing dry ice in the bunkers did not appear to lower air-blast temperatures.

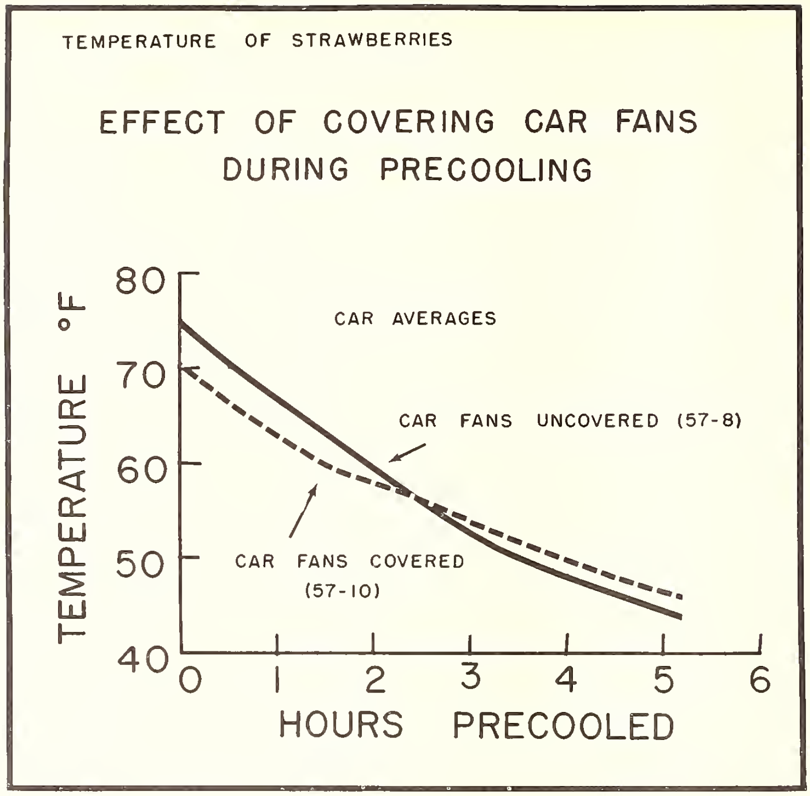

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Figure 6

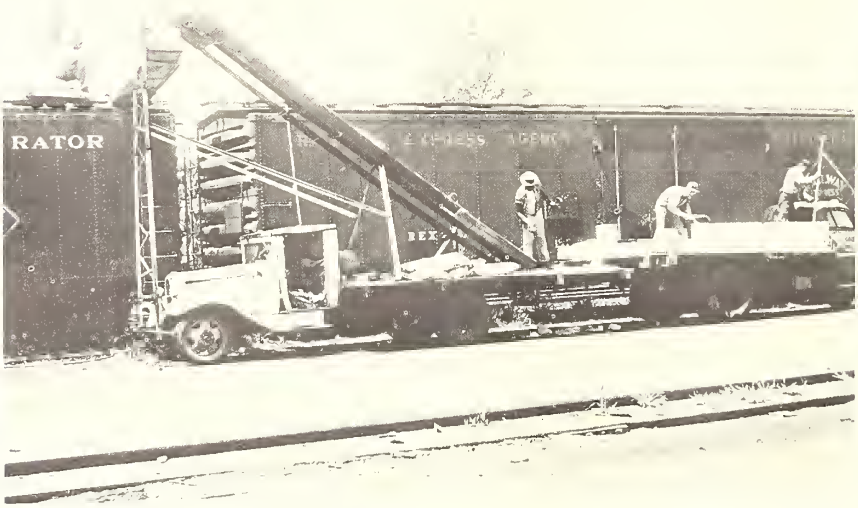

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Figure 7.--Icing test car with homemade ice conveyor.

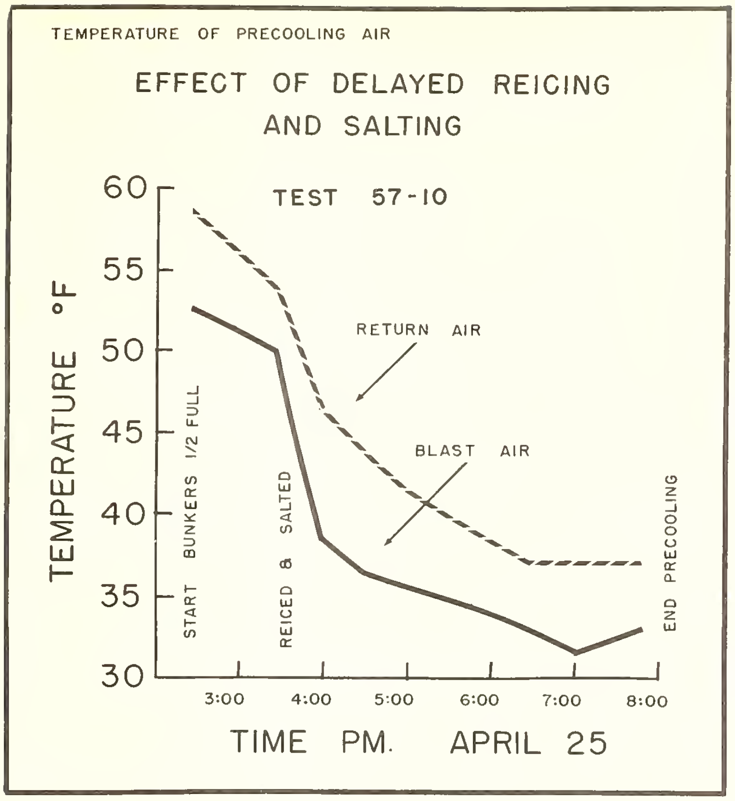

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Figure 8

Rail transit tests

The main objective of the transit tests was to determine the amount and rate of additional cooling provided by the car fans after the car started moving in transit. The first express car of the season moved on March 1 in 1957. However, in 1958, the first car didn't move until April 4, because an abnormally cool winter and spring delayed ripening of the berries. During both seasons, peak movement was reached during the last week in April. Normally cool weather prevailed during transit. Destinations of the test cars ranged geographically from Kansas City to Boston with 7 of the 17 tests going to the New York area. Detailed transit temperatures are presented in table 7, and a summary of these data showing rate of cooling is given in table 8.

Cooling rate

In general, cooling of the berries continued at a steady rate after transit movement began, but it was slower than during precooling. The time required for the average fruit temperature to reach 40° F. was computed for each car (table 8) and was found to vary from 9 hours for cars in tests 58-9 and 58-14 to 28 hours for test 58-3. However, the wide spread between top and bottom temperatures in test 58-3 indicates that the fans were not operating properly. Tests 58-4 and 58-8 both required 20 hours for the temperature to reach 40°. Test 58-4 moved without salt which probably slowed cooling, while 58-8 was only precooled for 1 hour and 55 minutes. In the tests with the rapid cooling, both 58-9 and 58-14 received 3 percent salt at first reicing and were precooled for over 5 hours. Figure 9 compares the transit cooling of tests 58-4 and 58-14. The data in all 17 tests were averaged and show the following: (1) Precooling time was 3 hours 53 minutes; (2) loading temperature was 79°; (3) temperature after precooling was 53°; (4) time to reach 40° was 14 hours; and (5) cooling rate was 1.02 degrees per hour. If we use

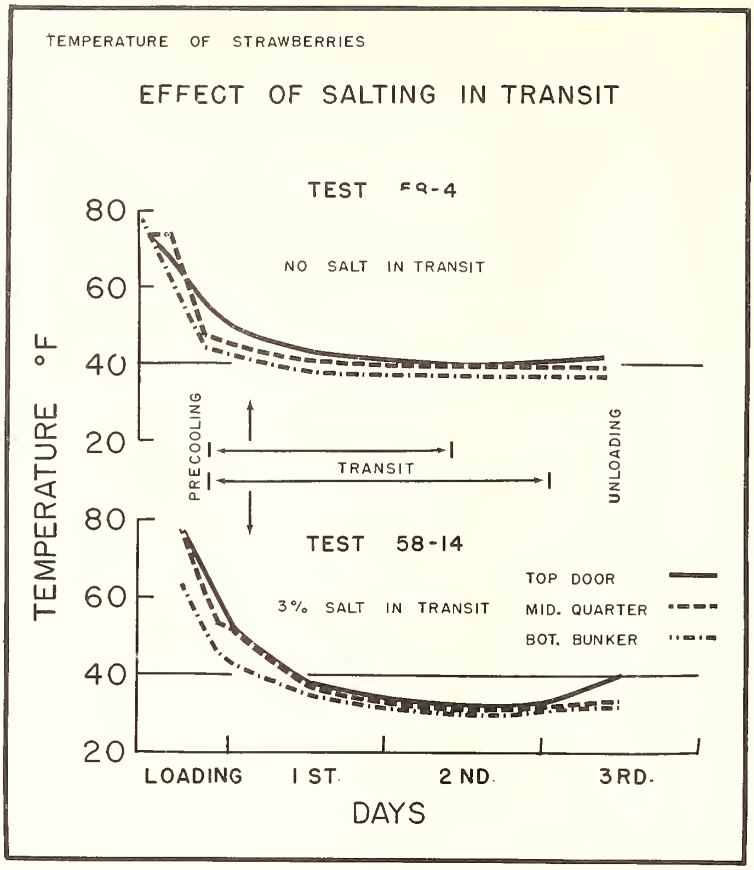

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Figure 9

these averages and assume there will be no prolonged interruptions for icing during precooling, no less than 200 pounds of salt for precooling will be used; 2 to 3 percent of salt will be added in transit for at least the first reicing; and the car will be forwarded by 10 p.m. on loading day; it is reasonable to expect the further cooling in transit will be about 1 degree per hour and that the average load temperature will be at or below 40° by noon of the first day in transit.

Upon arrival at destination, average fruit temperatures were generally in the range of 34° to 38° F. When a car was held for 2 or 3 days before unloading, temperatures rose from 2 to 4 degrees in the top layer. Although the berries in some cars were cooled as low as 30°, no general freezing damage was reported.

Car fans

Transit temperatures were fairly uniform because of good air circulation from the car fans. The notable exception was, as previously pointed out, in test 58-3 where it is evident the car fans were not operating properly. The transit data show that the performance of the newer cars equipped with four electric fans equalled that of the cars with six fans.

Transit refrigeration service

Cars shipped during the early part of April moved without salt, but as the weather warmed 2 percent salt was added in transit, and later 3 percent. This schedule was usually adequate although the addition of salt would undoubtedly have been beneficial in test 54-4. Salting of the ice is desirable up to and including the first reicing in transit as shown by the excellent cooling in tests 58-10 and 58-15, which were not salted beyond Memphis, the first reicing station. Bunkers were usually filled with ice after precooling before departure of the car from the loading area, but there were two or three instances where reicing was done before the end of precooling.

Dry ice

Very little of the dry ice remained in the loading space by the time the cars were unloaded. Freezing damage to berries was reported in one car where the dry ice was placed within 2 or 3 inches of the crates in the top layer next to the doorway brace. Because there were no check cars shipped without dry ice, no evaluation of possible benefits of the CO_2 can be made. Because of the low concentrations of CO_2 gas found in the precooling tests (4.5 percent maximum), it is unlikely that the concentration in transit was built up to the minimum of 10 percent required for effective decay control for strawberries.

Arrival condition

Test packages in nine of the cars were examined in detail by U. S. Department of Agriculture market laboratory personnel. The results tabulated below show relation between temperature and total decay of berries upon arrival.

Test No.	Percent of decay on arrival	Hours required in transit after precooling for berries to reach 40° F.	Average transit temperature, °F.
57-1	19.4	16	39.2
58-15	12.5	13	38.5
58-12	10.1	13	39.2
58-1	7.2	12	37.8
58-10	5.2	11	34.7
58-5	2.4	12	37.3
58-14	1.7	9	35.4
58-7	0	10	34.2

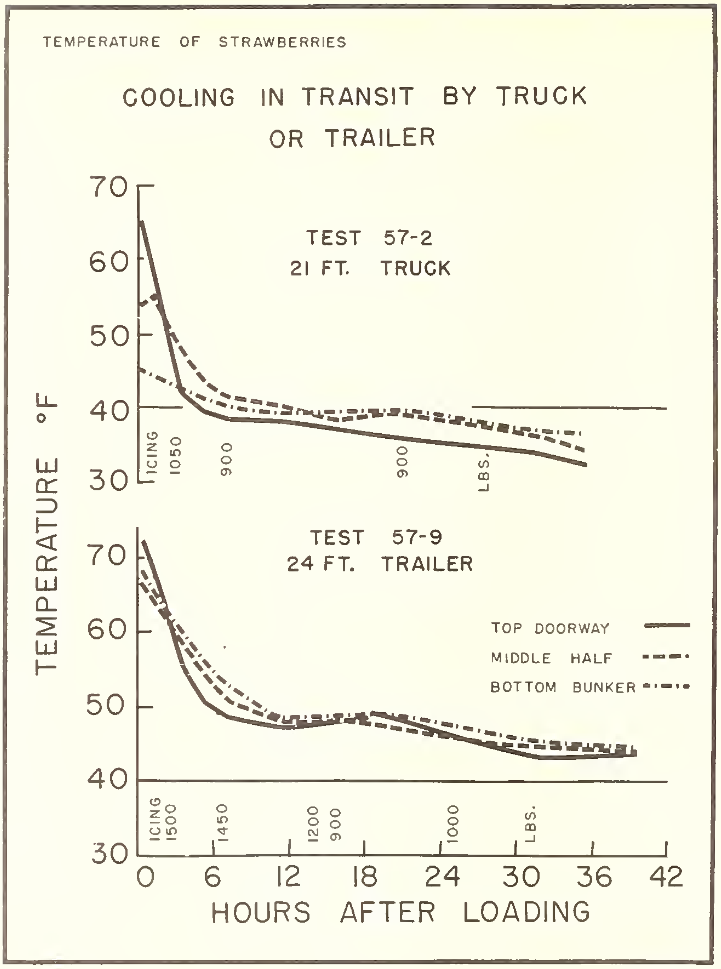
Total decay of berries was usually higher in cars having a slower cooling rate and higher average transit temperature. Berries held at room temperature for 24 hours decayed rapidly, ranging from 5 to 75 percent, and after 48 hours, from 19 to 100 percent. Principal decays were Botrytis and Rhizopus with Botrytis being more prevalent.

Truck-shipping tests

These tests were made only during the 1957 season from April 3 to 24. Weather conditions were about normal for that time of year. Both trucks and semi-trailers were loaded at four locations in the producing area and carried berries to New York or Chicago. The data from these tests are presented in tables 9 and 10.

Cooling rate

Average berry temperature at loading ranged from 59° to 80° F. which indicates the range of weather at loading point. The average load temperature (average of bottom bunker, middle half, and top doorway positions) was reduced to 40° by midnight of the day of loading in only one test 57-2 (fig. 10). This was in a 10-wheel truck in excellent condition and equipped with a 3,000-pound capacity ice bunker as compared with the 1,800- to 2,000-pound capacity bunkers in the other test vehicles. An average of 40° was reached by midnight of the first day in transit (about 30 hours after loading) in five of the tests, but the temperature remained above this point throughout transit in the remaining three trucks. Transit temperatures for one of these trucks (57-9) is also shown in figure 10. Average fruit temperature at destination varied from 34° to 44° and the reduction in



7137-59 (4)

Figure 10

temperatures during transit ranged from 29 to 41 degrees. In general, the top-doorway position cooled the most rapidly as it was in the most direct line with the air-blast from the blower. The bottom bunker position cooled several degrees during the loading operation because of natural convection currents. After the blower was started, the colder air from the bunker was replaced by warmer air, increasing berry temperatures temporarily in several trucks (table 10).

Transit refrigeration

The truck drivers were usually instructed to fill the ice bunkers every 6 to 8 hours in transit. In most of the tests the bunkers were filled just before the trucks were dispatched to the loading point and were refilled soon after loading, before starting over the road. Total ice usage, as reported by the drivers, varied from 3,250 pounds in one truck sent to Chicago to 8,800 pounds in another destined for New York (table 9), In some test trucks from 200 to 400 pounds of dry ice was placed in the bunkers on top of the bunker ice. No dry ice was reported remaining at destination. The data do not indicate that dry ice gave any more rapid cooling or resulted in lower fruit temperatures.

Arrival condition

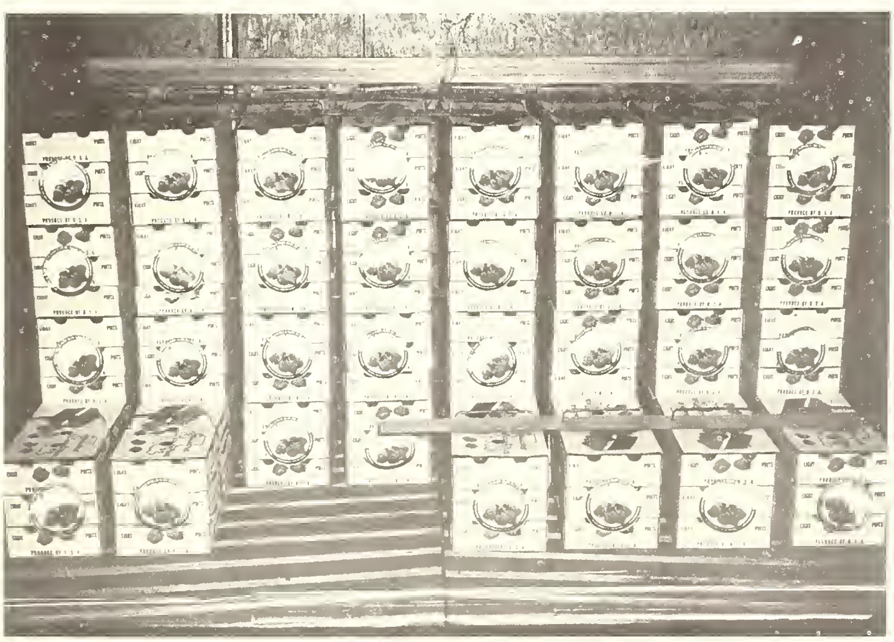
Most of the truck loads arrived at destination in good order, with little or no shifting or breakage. The decay reported on arrival varied from 7 percent during the early part of the season to 29 percent during the last week in April. The first examination of test fruit in some loads was delayed because of indefinite arrival time. This test fruit was held at room temperature for varying periods of time after unloading and before inspection. In shipments to Chicago, Rhizopus was the most prevalent decay; Botrytis (gray mold) was less common. In shipments to New York, gray mold was more prevalent. Total decay increased rapidly during the 2-day holding period at 70° at destination and ranged from 35 to 100 percent. Incidence of decay did not appear to be directly related to transit temperatures.

Experimental Containers

A full report on the marketing study of the three experimental containers is being prepared by the Department of Agricultural Economics, Louisiana State University. It will give a detailed description of the containers, their costs, marketing, consumer acceptance, etc. Only the data pertaining to loading and transit conditions will be presented in this report.

Container A

The first container tested was a fiberboard tray 10 x 18 1/2 x 3 1/2 inches holding 8 pints of berries. A metal carrying strap was fastened across the center of the tray. For shipping, three trays were stacked and held together by metal straps running from the top to the bottom tray on each side adjacent to the handles. This made a unit of 24 pints very close to the dimensions of the standard 24-pint wirebound berry crate. Air movement into each tray was permitted by two scallop-shaped openings measuring approximately 3/4 x 3 1/2 inches along the top of each side, with 2 smaller openings at the top of each end. A fiberboard cover was placed on the top tray of each unit to protect the berries during handling. They were loaded the same as the standard crate; lengthwise, 8 wide, 4 high with 3 to 4 inch channels between rows as shown in figure 11. A total of 352 3-tray units were loaded into one end of car in which a similar number of standard crates were loaded in the opposite end (test 58-10). Alignment was maintained by the use of slotted fiberboard strips crosswise of the car on each layer, which fitted into the metal handles.



BN-8444x

Figure 11.--Container "A" loaded in express car (note slotted fiberboard spacer strips to hold rows in alignment).

To prevent vertical displacement, a 1- by 6-inch board was placed over each row under the tray handles, lengthwise of car on the top layer (fig. 12). The load arrived in good order without any reported displacement or damage.

BN-8442x

Figure 12. --Completed load of container "A" in express car. A 1- by 6-inch board covers the top of each row.

During precooling the fruit temperature in the trays was reduced 17 degrees and that of the crates in the opposite end of the car was reduced 13 degrees. The total precooling time was only 3 hours and the fans were off about one hour during reicing which began 25 minutes after precooling started. Average temperature reduction in transit for trays and crates was about the same. Figure 13 shows that tray-packed berries required 12 hours after precooling to reach 40° and the crate-packed berries required 11 hours. Arrival temperatures in New York were close to 30°.

Container B

The second container tested was a fiberboard tray holding 12 pints of berries. Dimensions were approximately 13 1/2 x 18 x 4 inches. Wire handles were located at each end of the tray. These trays were stacked with the handles of one layer extending into openings in the ends of trays in the layer next above, thus holding the stack in alignment (fig. 14). No lid was used on these trays. A total of 750 were loaded in the opposite end of car from the standard WB crates in test 58-14. These trays were placed crosswise of the car 10 high, 5 wide and in 15 stacks. No space was left between the first stack and the bunker bulkhead. This prevented air from circulating horizontally through the side openings in the trays (fig. 14) back to the bunker. Except for a 7-inch channel between the third and fourth rows formed by a separating frame to take up the crosswise space in load, there were no vertical channels left between rows as shown in figures 14 and 15. A regular brace or center gate was used at the doorway. No means to prevent vertical motion was used as was done with container A. As shown in figure 14 the sides of the trays were cut down to permit circulation of air over the berries.

It should be pointed out that air circulation in this car was not normal because air channels for the trays differed from those for the crates in the opposite end of the car.

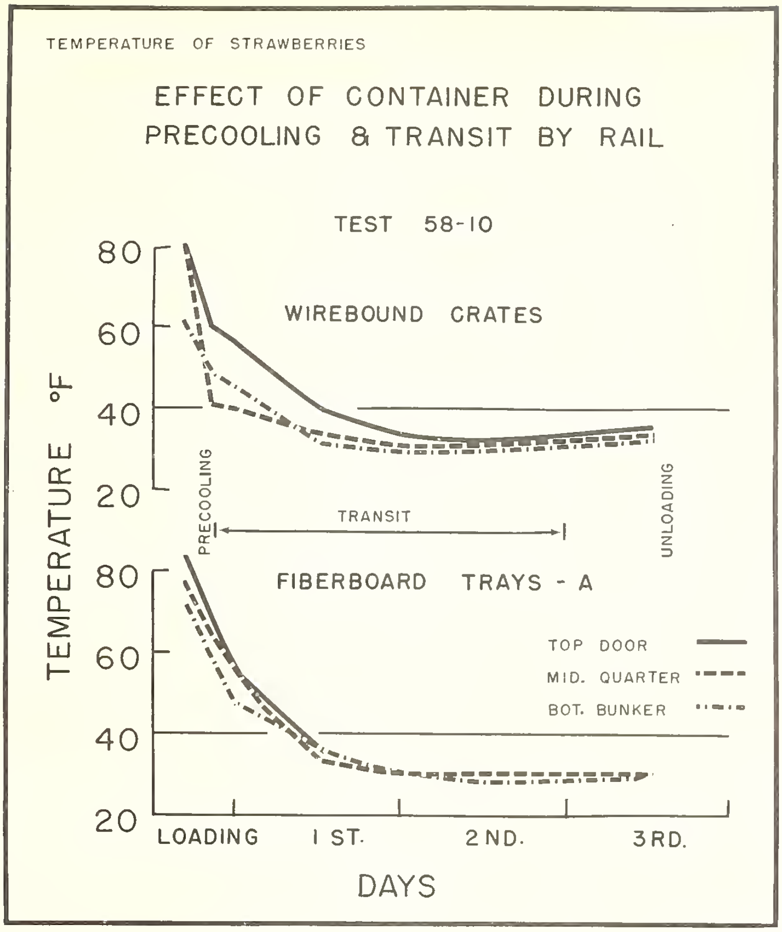


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Figure 13

Somewhat different cooling rates would be expected if the entire car were loaded with either trays or crates alone.

The results show that, with no vertical channels, and lengthwise air movement blocked by loading the trays tightly against the bulkhead, the berries in this end of car cooled quite slowly. In 5 hours of precooling the average temperature of the tray-packed berries was reduced 17 degrees as compared to 22.5 degrees in the more open crates in the other end of car. During in-transit cooling it required 22 hours to reduce the tray-packed berries to 40° and only 9 hours for the crated berries. After the first day, fruit temperatures were below 40°, averaging around 36° upon arrival. No significant damage or shifting was reported at destination. Transit temperatures are shown in figure 16.

Container C

This was also a fiberboard tray similar in design to container B, with wire handles in each end extending into openings in the tray above to maintain alignment. Two trays were fastened together by means of wire clamps to form a 24-pint unit. No lid was used with this tray. There were 750 12-pint trays (375 24-pint units) loaded in the opposite end of the car from the standard crates in test 58-15. They were loaded 10 high, 5 wide and in 15 stacks. In order to provide for the air circulation lengthwise of load that appeared to be lacking in the Container B test, 1" strips were nailed vertically on the bunker bulkhead with regular load stripping then nailed crosswise. This gave an air space of approximately 1 1/2 inches between the bulkhead and the first stack, thus

BN-7902

Figure 14. --Method of loading container B in express car. Lengthwise gate is used to take up crosswise slack.

permitting air to move lengthwise of the car from the doorway brace to the bunker, through the side openings in each layer of trays. These trays filled the space crosswise of the car so there were no vertical air channels between rows. They were not secured in any way to prevent vertical motion.

With apparent greater air movement through the load, the berries cooled more quickly and uniformly than those in Container B. Average temperature of the berries after precooling was 50° F. as compared with 52° for the standard crates in the other end of car. Both containers required 13 hours in transit after the finish of precooling, for the average temperature to reach 40° (fig. 17). Temperature at unloading was around 37° for each. The load arrived in good order with little or no package damage.

Fan Tests in Empty Cars

Limited fan tests were conducted to obtain a more definite measure of results from combinations of precooling fans and car fans in empty cars. Car fans were operated by 1- and 2-HP motors separately and in conjunction with the portable precooling fans, with corner car fans covered and uncovered.

Output from each fan was determined by measuring the velocity of air by means of velometers (air velocity meters). Average velocities were measured in horizontal and vertical sections across a car fan or across the delivery duct of a portable fan.

One-HP-capacity precooling motors are commonly used for operating the car fans in this area. A 2-HP motor recommended by the manufacturer for the electric-type fans was used in some of the tests. The 1-HP motor had a 3-3/4 inch diameter sheave and operated around 3,400 RPM. The 2-HP precooling motor was equipped with a 5-inch diameter sheave which turned at about the same speed as the 1-HP motor. The 1-HP motor operated the alternator on the car at speeds ranging from 1,500 to 1,710 RPM, whereas the 2-HP motor, with the larger diameter sheave, operated the alternator at speeds from 2,180 to 2,375 RPM--an increase of around 40 percent.

When the car fans were operated by a 1-HP motor, the average air volume measured was 2,018 cfm (cubic feet per minute). When a 2-HP motor was used, it was 2,528 cfm, an increase of 25 percent.

By combining the car fans (corner fans uncovered) with the portable fans the air delivery was 2675 cfm when a 1-HP motor was used on the car fans and 3443 cfm when a 2-HP motor was used, an increase of 33 and 36 percent respectively for the combined fans. Because it was difficult to provide a sufficiently large passage behind the canvas baffle to pull air from the corner car-fan openings, the output of the portable fans alone was not measured when used in a car with the 3 electric fans in each bulkhead. These cars with 6 electric fans are precooled most efficiently by using portable fans with the car fans, and leaving the corner car fans uncovered. When both portable and car fans were operated together, with the 2 corner fans covered by the canvas baffle (fig. 2) only 1,770 cfm of air delivery was obtained. By leaving both corner fans uncovered (fig. 1) so that they were not blocked by the canvas, the air flow was 2,808 cfm (1-HP motor for car fans), an increase of 59 percent.

While some tests were run on cars equipped with only four car fans instead of six, the data were inconclusive and no evaluation was considered feasible without further and more thorough tests.

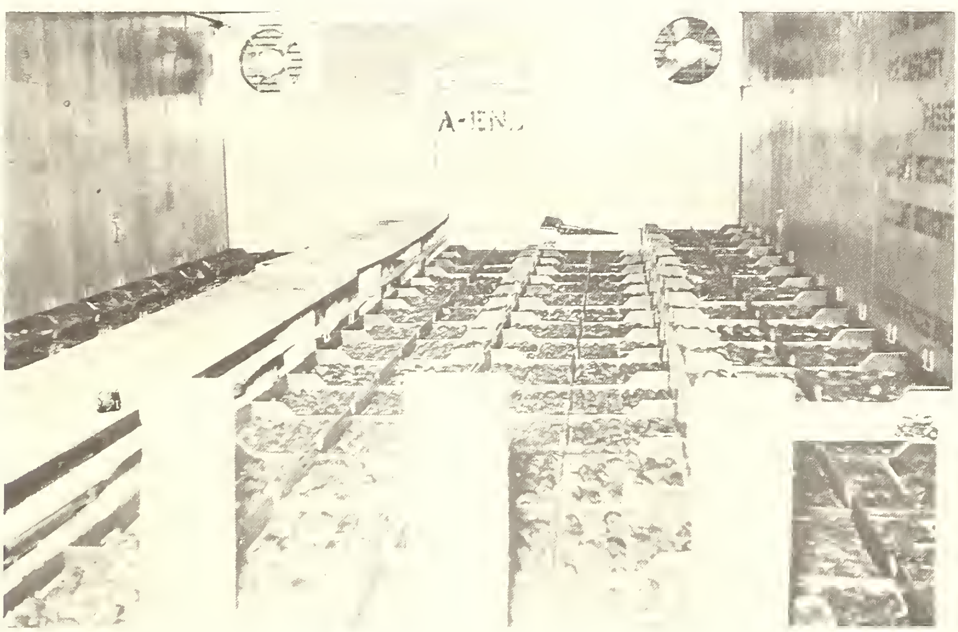

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Figure 15. --Container B loaded in express car showing catwalk for removal of portable precooling fan.

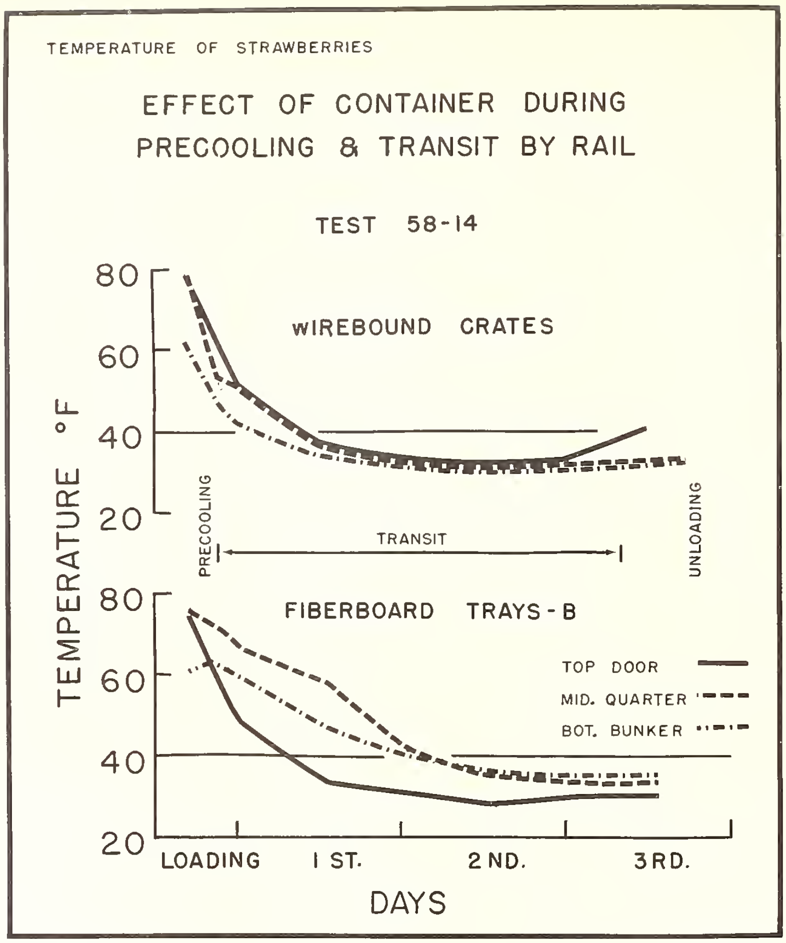

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Figure 16

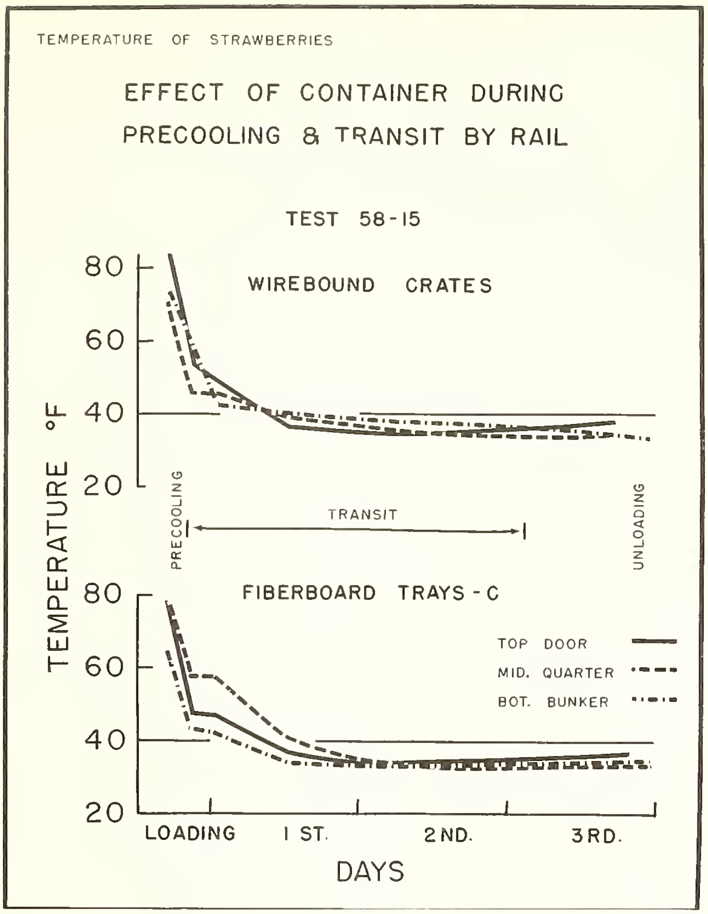

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Figure 17

DISCUSSION

The handling of strawberries grown in Louisiana and shipped to eastern and midwestern markets is reasonably efficient. The results of these tests permit evaluation of the precooling and shipping practices, and indicate phases of operation that need to be improved. Lack of proper and continuous supervision was, to some extent, responsible for many of the deficiencies in these tests.

Insufficient time was one of the major difficulties in precooling. Many cars were precooled only 2 to 3 hours. A minimum of 4 hours of continuous fan operation is considered desirable. Much of the lack of time was caused by late loading of the cars. The last cars must be loaded and braced not later than 4 p. m. to allow 4 hours of precooling, since pickup time is 8 p. m. The 4 p. m. loading deadline is difficult to meet.

While the test cars were in transit, the car fans cooled the berries at a fairly rapid rate. With an ordinary precooling job, the average temperature of the load was reduced in transit to 40° F. or below in from 8 to 12 hours or before noon of the first day in transit. It did not appear essential that cars be held past pickup time if berry temperatures at the doorway had not reached 40° by that time. As strawberries have a very short market life even when held at optimum temperatures, any delay in getting them to market should be avoided. In addition, timely or scheduled arrival on the market is essential for maximum financial returns

Both portable and car fans should be used for precooling because a faster cooling rate results from the increased air flow thus obtained. The use of a 2-HP motor to operate the electric car fans was shown to increase the air flow, and would probably provide sufficient cooling without the use of portable fans if allowed to blow at least 5 hours continuously. The use of portable fans only in a car equipped with electric fans, or the electric fans only driven by a 1-HP electric motor, is not adequate unless more precooling time is allowed.

When electric car and portable fans are used together, better results are obtained if the two corner fans are uncovered (in cars with three fans at each bulkhead). Covering these fans with the canvas baffles restricts the air movement. However, when cars are equipped with only two electric fans at each bulkhead, both of them must be covered when used in conjunction with the portable fans, with special care taken to provide the maximum space behind the canvas over each car fan to allow free air flow.

One difficulty noted in several instances, especially at one loading point, was the failure to reice the cars immediately after loading and before the precooling fans were started. Because the precooling fans had to be shut off during reicing, considerable precooling time was lost because of this delay.

Inefficiency in the icing operation may affect the refrigeration of the load. Good tamping poles or ice bars were not always provided. Inexperienced labor working without proper supervision was a problem in some cases. It is important to bar or chop down the old ice before reicing to avoid excessive voids in the remaining ice which would reduce the amount of ice in the bunkers. Partially filled bunkers will not give low air-blast temperatures.

Salt, 300 to 400 pounds per car, should be supplied just before precooling to get optimum low air-blast temperatures. When the transit protective service ordered calls for salt it does not appear to be necessary to supply any at initial icing when cars are preiced the day before loading, because its effect is lost by the time loading is completed. However, if the car is preiced on the day of loading, salt may be supplied to cool the car more quickly. There were many times during the 1958 season when dry cars, placed at the various loading points to take care of unexpected volumes of berries, were iced just before loading. There were many cases when the salt was not properly supplied before precooling. One third of the salt required should be added during the reicing before precooling and spread evenly over the old ice and worked into it. The bunkers should then be practically filled with ice, after which the remaining two-thirds of salt should be supplied and the bunkers then topped off with at least 6 inches of ice. Melting of the latter will start dissolving the salt immediately. It is the formation of brine from the salt and ice mixture, that lowers the temperature in the bunker.

Every effort should be made to prevent unnecessary loss of cold air from the car. Car doors should be kept closed when there is any appreciable delay in loading, and both doors should never be open at the same time. When reicing, only the number of bunkers which can be immediately serviced should be opened at one time. Loading on the sunny side of the car should be avoided if possible. The temperature drop of the berries loaded first at bottom bunker positions indicates the load will cool considerably during loading if good loading practices are followed.

A concentration of at least 10 percent of CO_2 for several hours is required for any effect in inhibiting decay and ripening of strawberries. The 400 to 500 pounds of dry ice used in these tests provided a maximum of 4.5 percent during precooling and most of this was undoubtedly lost when the doors were opened to remove the precooling fans and check temperatures. In California strawberry shipments, where 1,000 to 1,200 pounds of dry ice are used, maximum concentrations of 15 to 20 percent are commonly found and 10 percent or more for at least 24 hours is anticipated. Some refrigerating effect has been noted in tests with California berries with the larger amounts of dry ice, but the amount used for Louisiana berry shipments is believed to afford no significant additional cooling. Many of the blocks of dry ice used had been reduced by 10 or 15 pounds by the time they were placed in the cars so that a full 500 pounds seldom remained, when supplied. Placing blocks of dry ice in the bunkers is of doubtful value because of the absorption of the CO_2 gas by the drip water from the ice. Because of the very low temperature of the dry ice (-109° F.) it should never be placed closer than 6 inches from the berries or freezing damage will result.

Cooling continued at a fairly rapid rate after the cars started moving in transit, due to car fan operation. However, it should be remembered that when the fruit temperature reaches a point around 45°, the cooling rate is slower because of the smaller difference between the air-blast temperature and that of the fruit. For this reason it is important to use salt with the ice in warm weather, for at least the first reicing in transit. After the temperature of the berries is below 40°, the ice alone may be sufficient, unless the weather is hot. The use of 2 or 3 percent salt at all reicings during cool weather may result in dangerously low fruit temperatures.

The method of loading and bracing appears to be satisfactory and very little damage to the wirebound crates was reported at destination. There was some breakage in the gates or doorway braces, but no crates were damaged.

In the truck shipments, cooling rates varied considerably. For rapid cooling the bunker should be kept as full of ice as possible, especially during the first 24 hours, and the blower fan should operate at full speed. The loading method appears to be satisfactory from the standpoint of air circulation, but all lengthwise channels should be continuous or left open throughout the load. The doors should be closed if loading is interrupted for any length of time to conserve refrigeration and to speed cooling. After a truck or trailer is half-loaded, the blower engine should be started and run at low speed. This provides considerable cooling of the berries already loaded and the slow speed does not blow the cold air out the rear of the vehicle nor interfere unduly with the loaders. Because of lack of space, it is not possible to place dry ice on the load without serious danger of freezing. Placing the dry ice in the ice bunkers is of doubtful value, especially when only 100 to 200 pounds are used. As previously stated, high blower speed and full ice bunkers are of utmost importance during transit. While the data indicate large quantities of ice were used in some of the tests, the temperatures recorded lead one to question the icing records. The insulation and general condition of the vehicles were important factors in their performance. The truck making the best record was equipped with a 3,000-pound capacity ice bunker, contained approximately 2 to 3 inches of insulation, was in excellent condition and its operation was well supervised by the owner. Efficient cooling depends on the interest and ability of the driver to keep his vehicle in top condition and to supply enough ice in transit. The use of salt with the ice would speed up cooling but it does not appear to be practicable with the type of bunkers used and the brine drip would cause corrosion on the vehicle body and chassis. An accurate thermometer to indicate the temperature of the air returning to the bunker would enable the driver to know the temperature in his truck at all times.

All of the experimental containers tested appeared to cool adequately when properly spaced to provide air circulation. Cooling with container B was slow because the load was tight against the bulkhead and had no lengthwise vertical channels to allow air to move through the load. However, with a similar absence of vertical channels in the load for container C, a space provided between the bulkhead and the trays was sufficient to provide adequate air movement and cooling was satisfactory. All three loads arrived at destination in good condition so it appears that these containers may be loaded satisfactorily in express cars, although further testing by the railroads may be required. When no covering is provided for the trays (B and C) a special catwalk must be provided for the removal of the portable precooling fan as shown in figure 15.

RECOMMENDATIONS

Precooling in Express Cars

Reice bunkers to capacity before start of precooling. Bar or chop down old ice in bunkers to eliminate voids before putting in new ice. Add 300 to 400 pounds of coarse salt and tamp well into the ice.

Keep car doors closed except while actually loading. Never open both doors at the same time on an iced car. Load from shady side if possible. Open only the number of ice bankers that can be immediately serviced at one time.

Use both car and portable fans simultaneously for obtaining maximum cooling rate.

Operate electric car fans with 2-HP motor for precooling.

In cars with six electric fans, do not cover corner fans with canvas baffle of portable precooling fan.

When using portable fans in 4-fan electric fan cars, cover corner fans with canvas baffle but leave as much space as possible between car fans and canvas to permit maximum air delivery from the car fans.

If possible, operate precooling fans for at least 4 hours after loading.

If dry ice is used, do not place closer than 6 to 8 inches from the nearest berries. Do not place in bunkers.

Rail shipments

The use of salt with initial icing (pre-icing) is not necessary when the car is iced the day before loading. If the car is iced the same day as loading, salt should be supplied at initial icing (preicing) if the protective service ordered calls for salting in transit.

Use 2 or 3 percent salt to include at least the first reicing in transit in moderate weather and at all reicings when hot weather is expected during transit, especially if the berries are soft at loading or precooling is not thorough.

Truck shipments

Fill ice bunker to capacity immediately before loading and keep doors closed except while actually loading. Protect open doorway from direct sunshine as much as possible.

Run blower at low speed after one half of vehicle is loaded, then at full speed as soon as doors are closed after loading.

Leave at least 12 inches clear space above load and from 6 to 8 inches between load and rear doors for air movement. Be sure air channels through load are not blocked.

Replenish bunker with ice immediately after loading and keep as full as possible in transit, especially during the first 12 hours when the greatest cooling is required.

Do not put dry ice in bunker.

APPENDIX

TABLE 1.--Precooling record of Louisiana strawberries - April 1957[1]

Test No.	Railway express car (REX)	Car fans		No. of crates in car	Conditions in precooling			Precooling time	Outside temperature °F.	Fruit temperature °F				Avg. temp. reduction (degrees)
										At start of precooling[2]		At finish of precooling		
		Type	Number		Portable fans used	Car fans used	Corner car fans	Hrs. Min.		Range	Avg.	Range	Avg.	
57-1	7088	Elec.	6	768	Yes	No	Covered	3 - 10	61-67	55.0-67.0	63.9	37.0-52.5	44.1	19.8
57-2	6375	Floor	2	768	Yes	No	None	1 - 25	56-60	32.0-64.5	56.0	36.0-57.5	44.8	11.2
57-3	6999	Elec.	6	640	Yes	No	Covered	3 - 00	60-69	54.5-67.5	61.7	41.0-61.5	46.8	14.9
57-4	7299	Elec.	6	652	Yes	Yes	Uncovered	4 - 00	58-78	64.0-79.5	73.5	41.0-53.5	47.8	25.7
57-5	7111	Elec.	6	652	No	Yes[3]	Uncovered	5 - 40	63-78	55.0-72.0	65.6	40.0-57.5	47.1	18.5
57-6	6509	Floor	2	652	Yes	No	None	3 - 00	64-77	36.5-77.5	64.5	46.0-64.5	54.9	9.6
57-7	7253	Elec.	6	606	Yes[4]	Yes	Half covered	2 - 20	61-70	58.0-70.5	65.6	41.5-66.0	54.6	11.0
57-8	7309	Elec.	6	736	Yes	Yes	Covered	5 - 30	69-82	53.0-75.5	70.1	40.5-53.0	46.5	23.6
57-9	7086	Elec.	6	736	Yes[4]	Yes	Uncovered	2 - 45	72-77	51.0-78.5	70.6	41.0-68.5	57.4	13.2
57-10	7080	Elec.	6	672	Yes	Yes	Uncovered	5 - 25	75-83	64.0-81.5	75.4	38.0-57.5	44.9	30.5
57-11	7320	Elec.	6	736	Yes	Yes	Uncovered	2 - 05	75-78	55.0-77.5	71.8	46.0-68.5	56.8	15.0
57-12	6753	Floor	2	704	Yes	Yes[5]	None	2 - 35	75-85	56.5-78.0	73.0	34.0-60.5	45.9	27.1

[1] Cars nos. 5, 6, 10, 11, and 12 were reiced during precooling.
[2] Fruit temperatures in some locations in these cars had already been considerably lowered before start of precooling, especially at bottom bunker positions, as cars were initially iced and partially loaded well in advance of turning on precooling fans.
[3] 2-H.P motor used to operate car fans.
[4] No air delivery duct was used on portable fans.
[5] Car fans operated during loading.

Table 2.--Precooling record of Louisiana strawberries - April and May 1958[1]

Test No.	Railway express car (REX)	No. of car fans[2]	No. of pkgs.	Conditions in precooling			Precooling time		Outside temperature °F.	Fruit temperatures °F				Avg. temp. reduction (degrees)
				Portable fans used	Car fans used	Corner car fans	Hrs.	Min.		At start of precooling: Range	At start of precooling: Avg.	At finish of precooling: Range	At finish of precooling: Avg.	
58-1	7234	6	736	Yes	Yes	Uncovered	3	20	59-68	55.5-65.5	62.1	39.0-57.5	47.7	14.4
58-2	7702	4	640	Yes	Yes	Covered	3	40	60-63	64.5-68.5	66.9	50.0-59.0	54.0	12.9
58-2A	7345	6	707	Yes	Yes	Covered	3	00	61-71	61.5-65.5	63.0	43.0-56.0	48.9	14.1
58-3	6867	6	736	Yes	Yes	Uncovered	[3] 4	15	62-81	59.0-75.5	69.4	49.0-60.5	54.0	15.4
58-4	6842	6	640	Yes	Yes	Uncovered	4	45	66-80	60.5-75.0	68.6	40.5-57.5	48.1	20.5
58-5	7721	4	736	Yes	Yes	Covered	4	10	67-84	59.5-78.5	68.5	41.5-65.5	51.9	16.6
58-6	7889	4	608	Yes	No	Covered	1	30	63-70	No precooling temperatures taken				
58-7	7314	6	736	Yes	Yes	Uncovered	4	50	72-80	65.0-76.0	70.7	44.0-55.0	49.6	21.1
58-8	7282	6	687	Yes	Yes	Uncovered	1	55	73-76	61.0-80.5	72.3	54.0-68.5	61.3	11.0
58-9	7213	6	660	Yes	Yes	Uncovered	5	20	75-83	59.5-79.0	70.1	41.0-54.0	46.2	23.9
58-10	7381	6	[4] 704	Yes	Yes	Uncovered	3	30	80-89	57.5-85.5	77.8	48.0-74.5	57.9	[5] 19.9
58-11	7807	4	736	Yes	Yes	Covered	2	10	80-87	No precooling temperatures taken				
58-12	7816	4	736	Yes	No	Covered	4	15	71-78	62.0-79.5	74.5	41.5-64.5	53.2	21.3
58-13	7005	6	652	Yes	Yes[6]	Uncovered	4	00	71-78	63.0-90.0	77.4	42.5-66.5	50.9	26.5
58-14	7682	4	[4] 727	Yes	Yes	Covered	[7] 5	05	71-79	63.5-78.5	72.4	43.0-56.0	50.1	[5] 22.3
58-15	7093	6	[4] 695	Yes	Yes	Uncovered	[8] 3	45	73-81	Precooling temperatures incomplete				

[1] Cars nos. 1, 2, 4, 5, 7, 10, 11 and 14 were reiced during precooling.
[2] All were electric fans.
[3] Car and portable fans both actually in operation only 3 hours.
[4] These cars contained wirebound crates and fiberboard trays.
[5] Commodity temperatures and temperature reduction apply only to crates.
[6] 2-H.P. motor used to operate car fans.
[7] Car and portable fans both actually in operation only 3 hours, 50 minutes.
[8] Car fans actually in operation only 2 hours, 55 minutes; portable fans in operation 3 hours, 45 minutes.

TABLE 3.--Icing and salting record of precooling of Louisiana strawberries, April 1957

Test No.	Temp. reduction (degrees)	Water ice			Salt		Dry ice		
		Amount in bunkers at start of precooling	Lbs. supplied at reicing, during, or at finish of precooling	Time supplied	Amount supplied for precooling: Lbs.	Amount supplied for precooling: Time	Lbs. supplied	Time supplied before or during precooling	Location
57-1	19.8	8" space	900	At finish	200	At start	550	At start	Top of brace
57-2	11.2	Full	450	At finish	200	At start	500	At start	Floor & top of brace
57-3	14.9	Space	1,750	At finish	200	At start	594	25 min. after start	Top of brace
57-4	25.7	Full	1,800	At finish	400	At start	400	40 min. before finish	In bunkers
57-5	18.5	Full	1,800	1 hr. 20 min. before finish	200 100	At start 2 hrs. 20 min. before finish	none	-	-
57-6	9.6	Space	2,400	1 hr. 10 min. before finish	No record		400	1 hr. 20 min. after start	In bunkers
57-7	11.0	Space	1,500	At finish	200	1 hr. 10 min. before start	450	At start	Top of brace
57-8	23.6	Space	3,600	At finish	100	1 hr. 55 min. before start	450	1 hr. 50 min. after start	Top of brace
57-9	13.2	15" space	3,300	At finish	200	At start	450	At start	On floor
57-10	30.5	Space	5,400 2,100	1 hr.10 min.after start At finish	108	1 hr. 10 min. after start	400	1 hr. 25 min. before finish	In bunkers
57-11	15.0	Full	2,000	40 min. before finish	96	55 min. before start	400	50 min. after start	In bunkers
57-12	27.1	Slight space	No record 2,400	1 hr.10 min.after start At finish	300	At start	450	30 min. before start	Top of brace

TABLE 4.--Icing and salting record for precooling of Louisiana Strawberries - April 1958

Test No.	Temp. reduction °F.	Water ice			Salt			Dry ice		
		Total lbs. supplied at preicing and at reicing before or during precooling	Time initial icing before precooling	Time reicing before or during precooling	Lbs. supplied at initial icing and reicing before precooling	Amount supplied at start of or during precooling: Pounds	Amount supplied at start of or during precooling: Time	Lbs. supplied	Time supplied before or during precooling	Location
58-1	14.4	18,100	2 days	At start & during	None	200	At start	450	1 hr. after start	Floor & top of brace
58-2	12.9	15,300	4 hrs.	1/4 hr. before finish	None	300	At start	425	At start	On floor
58-2A	14.1	12,900	6 1/2 hrs.	None	None	300	At start	500	At start	On floor
58-3	15.4	21,080	3 days	1 1/4 hrs. after start and during	285	400	1 1/4 hrs. after start	250	1 hr. before finish	Top of brace
58-4	20.5	18,480	4 1/4 hrs.	1/4 hr. before finish	None	300	At start	480	1 1/4 hrs. after start	On floor
58-5	16.6	15,300	1 day	1/4 hr. before start	None	300	1/4 hr. before start	500	1 hr. before finish	Top of brace
58-6	([1])	15,300	1 day	3 1/2 hrs. before start	306	200	At start	480	1 hr. after start	On floor
58-7	21.1	17,700	2 days	1 1/2 hrs. after start	258	200	1 1/4 hrs. after start	500	2 hrs. after start	Floor and top of brace
58-8	11.0	12,900	8 hrs.	None	387	200	1/2 hr. before start	500	At start	Floor and top of brace
58-9	23.9	12,900	4 1/2 hrs.	None	387	200	1/4 hr. after start	400	2 hrs. after start	On floor
58-10	[2] 19.9	19,200	1 day	1 1/4 hrs. after start	387	400	3/4 hr. after start	500	At finish	On floor
58-11	([1])	15,900	1 day	3/4 hr. after start	387	200	3/4 hr. after start	500	1/2 hr. after start	Floor and top of brace
58-12	21.3	16,800	2 days	3 hrs. before start	504	300	At start	500	1/4 hr. after start	Top of brace
58-13	26.5	17,400	9 hrs.	1 hr. after start	387	300	1 hr. after start	450	At start	On floor
58-14	[2] 22.3	18,300	1 day	At start	387	400	1 hr. after start	500	At start	Top of brace
58-15	([3])	14,400	8 1/2 hrs.	At start	387	300	At start	500	3/4 hr. after start	Top of brace

[1] No precooling temperatures taken - transit test only.
[2] Applies only to crates - these cars also contained cartons.
[3] Precooling temperatures incomplete.

TABLE 5.--Precooling time and temperatures of air and fruit, Louisiana strawberries, April 1957

Test No.	Car fans		Precooling time	Car air temperatures °F						Average fruit temperatures °F								Temperature reduction (degrees)			
				Start of precooling			End of precooling			Start of precooling				End of precooling							
	Type	No.	Hrs. - Min.	Blast	Return	Diff.	Blast	Return	Diff.	Top	Middle	Bottom	Car avg.	Top	Middle	Bottom	Car avg.	Top	Middle	Bottom	Car avg.
57-1	Elec.	6	[1] 3 - 10	43.5	53.5	10.0	35.5	41.0	5.5	65.2	65.7	60.7	63.9	38.2	48.8	45.3	44.1	27.0	16.9	15.4	17.8
57-2	Floor	2	[1] 1 - 25	36.5	45.0	8.5	33.0	43.0	10.0	61.7	60.0	46.3	56.0	41.0	48.5	45.0	44.8	20.7	11.5	1.5	11.2
57-3	Elec.	6	[1] 3 - 00	43.0	52.5	9.5	33.5	41.0	7.5	63.0	64.3	57.8	61.7	44.5	50.0	45.8	46.8	18.5	14.3	12.0	14.9
57-4	Elec.	6	4 - 00	45.0	53.5	8.5	34.5	39.0	4.5	76.7	77.8	66.2	73.5	45.3	51.0	47.2	[illegible]	31.4	26.8	19.0	25.7
57-5	Elec.	6	[2,3,4] 5 - 40	47.0	53.5	6.5	33.5	36.5	3.0	69.0	68.8	59.0	65.6	46.0	51.2	44.2	47.1	23.0	17.6	14.8	18.5
57-6	Floor	2	[1] 3 - 00	53.0	55.0	2.0	43.5	49.0	5.5	70.0	70.7	52.8	64.5	50.8	59.3	54.7	54.9	19.2	11.4	1.4 (Rise)	[illegible]
57-7	Elec.	6	[5] 2 - 20	46.5	54.0	7.5	40.5	43.0	2.5	65.5	67.5	63.7	65.6	54.5	58.7	50.5	54.6	11.0	8.8	13.2	[illegible]
57-8	Elec.	6	5 - 30	44.0	58.0	14.0	38.5	43.5	5.0	74.0	73.3	63.0	70.1	46.8	47.0	45.8	46.5	27.2	26.3	17.2	[illegible]
57-9	Elec.	6	[5] 2 - 45	50.0	53.0	3.0	36.5	42.0	5.5	77.2	75.0	59.7	70.6	60.0	60.2	52.0	57.4	17.2	14.8	7.7	13.2
57-10	Elec.	6	5 - 25	52.5	58.5	6.0	34.0	38.5	4.5	77.0	79.8	69.5	75.4	47.5	42.8	43.3	[illegible]	29.5	36.0	26.2	[illegible]
57-11	Elec.	6	2 - 05	53.5	59.5	6.0	41.5	48.5	7.0	76.0	75.0	64.5	71.8	54.5	59.3	56.7	[illegible]	21.5	15.7	7.9	[illegible]
57-12	Floor	2	[6] 2 - 35	37.5	52.0	14.5	33.0	37.0	4.0	75.5	76.3	67.3	73.0	43.7	49.8	44.2	45.9	31.3	26.5	23.1	27.1
				Grand average (12 cars)						70.9	71.2	60.9	67.6	47.7	52.3	47.9	49.3	23.2	18.9	13.3	18.3

[1] Only portable fans used in precooling.
[2] 2 H.P. motor used to operate electric car fans.
[3] Car fans only used in precooling.
[4] Car fans actually in operation 5 hours 15 minutes.
[5] No air delivery duct used on portable fans.
[6] Car fans actually in operation 4 hours 35 minutes which included 2 hours of operation during loading period.

TABLE 6.--Precooling time and temperatures of air and fruit - Louisiana strawberries - April and May 1958

Test No.	No. car fans[1]	Precooling time	Car air temperatures °F						Average fruit temperatures °F								Temperature reduction (degrees)			
			Start of precooling			End of precooling			Start of precooling				End of precooling							
		Hrs. - Min.	Blast	Return	Diff.	Blast	Return	Diff.	Top	Middle	Bottom	Car avg.	Top	Middle	Bottom	Car avg.	Top	Middle	Bottom	Car avg.
58-1	6	3 - 20	42.0	54.0	12.0	36.5	43.5	7.0	63.8	62.5	60.0	62.1	41.0	52.2	49.8	47.7	22.8	10.3	10.2	14.4
58-2	4	3 - 40	51.0	58.5	7.5	40.0	48.5	8.5	67.3	67.7	65.7	66.9	54.3	55.2	52.5	54.0	13.0	12.5	13.2	12.9
58-2A	6	3 - 0	42.0	51.5	9.5	34.5	39.5	5.0	62.3	64.5	62.2	63.0	47.5	50.8	48.3	48.9	14.8	13.7	13.9	14.1
58-3	6	[2] 4 - 15	51.0	55.0	4.0	39.5	47.0	7.5	73.2	71.3	63.8	69.4	55.2	54.3	52.5	54.0	18.0	17.0	11.3	15.4
58-4	6	4 - 45	43.0	53.0	10.0	35.5	40.0	4.5	68.7	72.5	64.7	68.6	46.0	51.0	47.2	48.1	22.7	21.5	17.5	20.5
58-5	4	4 - 10	43.5	56.0	12.5	36.5	42.0	5.5	68.0	71.3	66.2	68.5	45.8	57.8	52.2	51.9	22.2	13.5	14.0	16.6
58-7	6	4 - 50	53.0	56.5	3.5	38.0	45.0	7.0	70.3	73.5	68.2	70.7	47.8	49.8	51.2	49.6	22.5	23.7	17.0	21.1
58-8	6	1 - 55	47.0	62.0	15.0	44.0	53.5	9.5	76.5	77.7	62.7	72.3	63.7	64.8	55.3	61.3	12.8	12.9	7.4	11.0
58-9	6	5 - 20	46.0	53.5	7.5	Data incomplete			73.0	70.5	66.8	70.1	45.5	46.7	46.3	46.2	27.5	23.8	20.5	23.9
58-10	6	3 - 30	43.0	49.5	6.5	38.5	46.0	7.5	83.0	83.5	66.8	77.8	57.8	61.7	54.3	57.9	25.2	21.8	12.5	[3] 19.9
58-12	[4] 4	4 - 15	40.5	56.0	15.5	36.0	43.5	7.5	77.8	77.3	68.3	74.5	51.0	57.5	51.2	53.2	26.8	19.8	17.1	21.3
58-13	[5] 6	4 - 00	50.0	57.5	7.5	36.0	41.0	5.0	79.0	83.2	70.0	77.4	47.7	54.7	50.2	50.9	31.3	28.5	19.8	26.5
58-14	4	[6] 5 - 05	47.0	53.5	6.5	38.0	40.0	2.0	76.2	76.2	64.8	72.4	52.8	52.5	45.0	50.1	23.4	23.7	19.8	[3] 22.3
Grand average (13 cars)									72.2	73.2	65.4	70.2	50.5	54.5	50.5	51.8	21.8	18.7	14.9	18.4

[1] All were electric fans.
[2] Car and portable fans both actually in operation only 3 hours.
[3] Fruit temperatures and temperature reduction apply only to crates.
[4] Portable fans only used in precooling this car.
[5] 2 H.P. motor used to operate car fans.
[6] Car and portable fans both actually in operation only 3 hrs. 50 min.

TABLE 7.--Transit data and temperatures of Louisiana strawberries shipped in railway express cars - 1957-58

Test	Car (REX)	Loading date and time	Destination	Position of thermometer in load[1]	Loading temp.	Temperature, °F, days after loading: Loading day, midnight	1st day Noon	1st day Mid-night	2nd day Noon	2nd day Mid-night	3rd day Noon	3rd day Mid-night	4th day Noon	4th day Mid-night	5th day Noon	5th day Mid-night	6th day Noon	6th day Mid-night
Year - 1957																		
57-1	7378	April 19 3:00 PM	Chicago	BBCL	85	45	38	35	33	31	31	[2] (4 AM)						
				MQCL	86	50	40	37	38	39	38	[2] (3 AM)						
				TDCL	86	56	44	42	42	41	41	[2] (2 AM)						
				Car avg.	86	50	41	38	38	37	37							
57-2	7080	April 25 2:20 PM	Boston	BBCL	81	40	35	36	38	37	[3] 36	34	34	36	36	37	38	[2] (10 AM)
				MQCL	83	45	39	37	38	38	39	39	40	41	41	42	42	[2] (10 AM)
				TDCL	81	57	45	42	41	41	41	45	44	42	41	41	41	[2] (10 AM)
				Car avg.	82	47	40	38	39	39	39	39	39	40	39	40	40	
Year - 1958																		
58-1	7234	April 12 1:30 PM	New York	BBCL	76	42	35	34	34	35	35	35	34	34				
				MQCL	74	46	39	36	35	35	36	37	38					
				TDCL	74	54	40	36	35	37	38	41	40					
				Car avg.	75	47	38	35	35	36	36	38	37					
58-2	7702	April 14 4:00 PM	Pittsburgh	BBCL	65	48	38	37	37	37	37	[2] (11 AM)						
				MQCL	75	48	35	35	34	35	36	[2] (5 AM)						
				TDCL	66	50	40	37	36	38	38	[2] (3 AM)						
				Car avg.	69	49	38	36	36	37	37							
58-3	6867	April 17 1:00 PM	New York	BBCL	79	43	34	33	34	34	34	34	34					
				MQCL	68	52	46	42	41	41	41	-	-					
				TDCL	63	54	49	46	44	43	42	-	-					
				Car avg.	70	50	43	40	40	39	39	-	-					
58-4	6842	April 18 Noon	Pittsburgh	BBCL	78	43	38	38	38	38	38	[2] (9 AM)						
				MQCL	73	45	41	40	40	40	40	[2] (9 AM)						
				TDCL	70	50	43	41	40	42	43	[2] (9 AM)						
				Car avg.	74	46	41	40	39	40	40							
58-5	7721	April 19 Noon	New York	BBCL	78	43	34	34	34	35	35							
				MQCL	75	50	35	34	35	36	37							
				TDCL	70	48	40	34	34	35	37							
				Car avg.	74	47	36	34	34	35	36							
58-6	7889	April 19 4:00 PM	Boston	BBCL	85	49	30	31	31	33	33	33	32	32	32	[2] (10 AM)		
				MQCL	76	64	42	33	Clock stopped			-	-	-	-			
				TDCL	75	53	39	35	34	37	38	39	40	[2] (8:30 AM)				
				Car avg.	79	55	37	33	33	35	36	36	36	-	-			
58-7	7314	April 21 Noon	New York	BBCL	75	45	34	31	Clock stopped									
				MQCL	84	46	34	32	30	31	32	32	[2] (3 PM)					
				TDCL	89	45	35	33	30	32	32	35	[2] (2:30 PM)					
				Car avg.	84	45	34	32	30	32	32	-						
58-8	7282	April 21 5:00 PM	Detroit	BBCL	87	52	41	37	35	[2] (10 AM)								
				MQCL	76	55	42	39	Clock stopped 4:00 PM									
				TDCL	72	56	45	37	33	[2] (10 AM)								
				Car avg.	78	54	43	37	34									

See footnotes at end of Table.

TABLE 7.--Transit data and temperatures of Louisiana strawberries shipped in railway express cars - 1957-58--Continued

Year - 1958				Position of thermometer in load[1]	Loading temp.	Temperature, °F, days after loading												
Test	Car (REX)	Loading date and time	Destination			Loading day, midnight	1st day		2nd day		3rd day		4th day		5th day		6th day	
							Noon	Mid-night	Noon	Mid-night	Noon	Mid-night	Noon	Mid-night	Noon	Mid-night	Noon	Mid-night
58-9	7213	April 22 Noon	Detroit	BBCL	82	38	33	33	34									
				MQCL	81	42	34	34	35									
				TDCL	82	48	38	36	38									
				Car avg.	82	43	35	34	36									
58-10	7381	April 24 Noon[4]	New York	BBCL	85	45	31	29	30	31	32	[2] (7 PM)						
				MQCL	82	40	32	30	31	32	33	[2] (7 PM)						
				TDCL	81	56	39	33	31	33	35	[2] (5 PM)						
				Car avg.	83	47	34	31	31	32	33							
58-11	7807	April 24 2:00 PM	Kansas City	BBCL	80	52	37	34	34	34	34	[2] (6 AM)						
				MQCL	84	56	39	36	39	[2] (10 AM)								
				TDCL	87	72	45	41	38	[2] (8 AM)								
				Car avg.	84	60	40	37	37	-	-							
58-12	7816	April 25 4:00 PM	Chicago	BBCL	90	49	35	30	30	30	30	30						
				MQCL	83	65	40	40	37	37	37	37						
				TDCL	79	55	44	43	37	37	37	37						
				Car avg.	84	56	40	38	35	35	35	35						
58-13	7005	April 26 2:00 PM	Buffalo	BBCL	84	46	35	32	33	34	34	34	35	[2] (8 AM)				
				MQCL	82	46	36	36	35	36	38	38	38	[2] (8 AM)				
				TDCL	82	54	40	38	36	36	40	39	38	[2] (8 AM)				
				Car avg.	83	49	37	35	35	35	37	37	-					
58-14	7682	April 28 2:00 PM[4]	New York	BBCL	80	42	34	31	30	32	32	32	[2] (5 PM)					
				MQCL	90	51	36	32	30	32	32	32	[2] (5 PM)					
				TDCL	86	51	36	33	31	32	40	[2] (11 AM)						
				Car avg.	85	48	35	32	30	32	-	-						
58-15	7093	May 1 2:00 PM[4]	New York	BBCL	76	43	39	38	38	37	37	35	[2] (11 PM)					
				MQCL	85	46	39	37	36	36	36	36	[2] (4 PM)					
				TDCL	87	47	37	36	36	37	38	39	[2] (4 PM)					
				Car avg.	83	45	38	37	37	37	37	-						

[1] Thermometer position designations-
BBCL - Bottom bunker-centerline of car
MQCL - Middle quarterlength-centerline of car
TDCL - Top doorway-centerline of car
[2] Time thermometer removed from car.
[3] Car arrived Boston PM of April 28 - unloaded throughout 3 days.
[4] Temperatures in standard wirebound crates.

TABLE 8.--Precooling and transit data and cooling rate in transit of Louisiana strawberries shipped in express cars under standard refrigeration - April-May, 1957-58

Test No.	Loading date	No. of car fans	Precooling time	Average temperature			Time after precooling for car temp. to reach 40°	Salt applied in transit	Destination	Time in transit	Cooling rate to 40° F
				At loading	After precooling	1st midnight					
	1957		Hrs. - Min.	°F	°F	°F	Hours	Percent		Hours	°F/Hr.
57-1	April 19	6	4 - 00	86	52	50	16	None	Chicago	28	.75
57-2	April 25	6	5 - 25	82	50	47	16	2	Boston	70	.63
	1958										
58-1	April 12	6	3 - 20	75	48	47	12	None	New York	48	.67
58-2	14	4	3 - 40	69	54	49	12	None	Pittsburgh	32	1.27
58-3	17	6	4 - 15	70	54	50	28	2	New York	44	[1] .50
58-4	18	6	4 - 45	74	48	46	20	None	Pittsburgh	32	.40
58-5	19	4	4 - 10	74	52	47	12	None	Waverly, N. J.	48	1.00
58-6	19	4	1 - 30	79	60	55	12	2	Boston	49	1.67
58-7	21	6	4 - 50	84	50	45	10	2	New York	55	1.00
58-8	21	6	1 - 55	78	61	54	20	2	Detroit	35	1.05
58-9	22	6	5 - 20	82	46	43	9	3	Detroit	34	.67
58-10	24	6	3 - 30	83	50	47	11	[2] 2	New York	48	1.10
58-11	24	4	2 - 10	84	71	60	17	3	Kansas City	35	1.83
58-12	25	4	4 - 15	84	53	56	13	3	Chicago	30	1.00
58-13	26	6	4 - 00	83	51	49	11	3	Buffalo	45	1.00
58-14	28	4	5 - 05	85	50	48	9	3	New York	59	1.11
58-15	May 1	6	3 - 45	83	50	45	13	[2] 2	New York	46	.77
Average of 17 Tests			3 - 53	79	53	49	14	-	-	-	1.02

[1] Fans apparently did not operate properly.
[2] No salt applied after 1st reicing.

TABLE 9.--Loading and transit data for truck shipping tests of Louisiana strawberries, April 1957

Test No.	Vehicle		Date	Origin	Loading data				Destination	Arrival date	Transit time	Strawberry temperatures					Ice meltage in transit
	Type	Inside length			No. crates	Ht. of load	Space above load	Outside air				At loading[1]		At destination[2]		Reduction	
												Range	Average	Range	Average		
		Ft. - Ins.	*April*			*Ins.*	*Ins.*	*°F*		*April*	*Hrs. - Min.*	*°F*	*°F*	*°F*	*°F*	*Degrees*	*Pounds*
57-1	Semi-trailer	32-0	3	Hammond	440	61	20	76-81	Chi.	5	29-45	77-79	78	38-40	39	39.0	4,650
57-2	Truck	21-3	10	Ponchatoula	493	70 1/2	17	62-69	Chi.	11	28-15	51-65	59	32-36	34	25.0	3,250
57-3	Truck	21-0	11	Ponchatoula	735	80	8 1/2	68-75	N.Y.	14	68-0	65-70	68	35-37	36	32.0	7,400
57-4	Truck	20-6	13	Albany	780	81	8	60-64	N.Y.	15	46-0	55-72	65	37-38	37	28.0	5,950
57-5	Semi-trailer	24-0	16	Albany	643	70 1/2	15	68-70	Chi.	17	28-30	68-71	70	38-43	41	29.0	5,250
57-6	Semi-trailer	29-6	17	Albany	875	80	14	78-80	Chi.	19	29-25	77-80	78	40-42	41	37.0	6,300
57-7	Truck	21-0	20	Hammond	752	80	9	75-82	N.Y.	23	49-0	77-81	80	37-40	39	41.0	7,000
57-8	Truck	21-5	23	Albany	711	79	12	77-81	N.Y.	25	46-30	76-82	79	39-40	39	40.0	8,800
57-9	Semi-trailer	23-8	24	Tickfaw	720	70	12	78-83	Chi.	25	28-0	77-80	79	44-44	44	35.0	7,000

[1] Hand thermometer readings.
[2] Recording thermometer readings.

TABLE 10.--Transit data and temperatures of Louisiana strawberries shipped by truck - April 1957

Test No.	Loading date and time	Destination	Position in load[1]	Loading day					Temperature (°F) specified days after loading										Hours required to reach 40°
									1				2		3		4		
				After loading	6PM	8PM	10PM	MT	4AM	8AM	Noon	MT	N	MT	N	MT	N	MT	
57-1	April 3 5:30 PM	Chicago	BBCL	71	70	62	59	56	50	46	45	41	40	[3](8AM)					16
			MHCL	([2])															
			TDCL	76	76	70	51	49	45	42	40	38	38	[3](2AM)					
			Average	73	73	66	55	52	47	44	42	39	39						
57-2	April 10 4:45 PM	Chicago	BBCL	45	44	42	41	40	39	39	39	36	36	[3](4AM)					6
			MHCL	54	55	48	43	41	40	38	39	36	34	[3](4AM)					
			TDCL	65	59	42	39	38	38	37	36	34	32	[3](4AM)					
			Average	55	53	44	41	40	39	38	38	35	34						
57-3	April 11 6:40 PM	New York	BBCL	65	-	56	52	49	45	42	41	40	38	37	37	36	37	(noon)	23
			MHCL	66	-	65	61	58	52	46	43	40	38	37	37	36	35	(10AM)	
			TDCL	64	-	60	50	48	44	41	40	39	37	36	37	(3PM)			
			Average	65		60	54	52	47	43	41	40	38	37	37	36	36		
57-4	April 13 5:30 PM	New York	BBCL	44	-	52	52	49	46	44	42	40	39	38	38	38	38	38 (8PM)	14
			MHCL	60	-	50	48	46	42	40	39	37	36	36	36	37	36	(5PM)	
			TDCL	65	-	47	43	41	40	39	37	36	36	35	36	37	(6PM)		
			Average	56		50	48	45	43	41	39	38	37	36	37	37	37		
57-5	April 16 6:00 PM	Chicago	BBCL	42	56	58	56	53	48	47	46	45	38	[3](11AM)					-
			MHCL	70	68	62	60	56	50	48	46	45	43	[3](5AM)					
			TDCL	70	70	58	54	50	48	46	46	44	43	[3](3:30AM)					
			Average	61	65	59	57	53	49	47	46	45	41						
57-6	April 17 5:30 PM	Chicago	BBCL	51	70	67	63	59	53	50	50	45	40	[3](10AM)					-
			MHCL	78	77	72	65	62	53	51	48	([2])	-						
			TDCL	80	75	65	61	56	50	48	47	42	42	[3](3:30AM)					
			Average	70	74	68	63	59	52	50	48	43	41						
57-7	April 20 6:30 PM	New York	BBCL[4]	78	78	77	71	65	56	51	47	43	42	41	40	40	41	41 (6PM)	30
			MHCL	70	67	66	61	55	45	40	39	38	37	37	37	37			
			Average	74	72	71	66	60	50	45	43	40	39	39	38	38			
57-8	April 23 4:00 PM	New York	MHCL[5]	81	71	61	55	50	46	43	41	39	40	40	(10PM)				18
			TDCL	82	70	52	48	45	44	40	40	38	39	39	(8PM)				
			Average	81	70	56	51	47	46	41	40	38	39	39					
57-9	April 24 5:00 PM	Chicago	BBCL	68	65	60	55	52	48	48	48	45	44	[3](noon)					-
			MHCL	67	65	59	54	50	48	48	47	45	44	[3](10AM)					
			TDCL	72	67	55	50	48	47	48	48	44	44	[3](8AM)					
			Average	69	66	58	53	50	48	48	48	45	44						

[1] Position designations:
BBCL - Bottom bunker centerline of truck.
MHCL - Middle half-way centerline of truck.
TDCL - Top door centerline of truck.
[2] Thermometer failed.
[3] Time thermometer removed from load.
[4] TDCL thermometer failed.
[5] BBCL thermometer failed.

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